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SURGERY

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THEORY AND PRACTICE

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THEORY AND PRACTICE

BY

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EIGHTH EDITION

WITH 622 ILLUSTRATIONS, INCLUDING 20 SKIAGRAM PLATES

BY

WALTER GEORGE SPENCER

M.S., M.B. (LOND.); F.R.C.S. ENG.

SURGEON TO THE WESTMINSTER HOSPITAL

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PREFACE TO THE EIGHTH EDITION.

MR. SPENCER having aided me in the preparation of the previous editions of this book, and my increasing engagements making it difficult for me to devote sufficient time to the work, I have, with the concurrence of the Publishers, asked him to take the larger share in the editing of the eighth edition, and now associate his name with my own on the title page.

The insertion of new matter which has recently come to be important has involved an increased number of pages and the addition of 139 illustrations.

Mr. Jessop and Mr. Cumberbatch have kindly revised the sections on Ophthalmic Surgery and on Aural Surgery. Illustrations which have been derived from other sources are duly acknowledged under each figure; additional skiagrams have been supplied by Dr. Hugh Walsham; the new drawings and diagrams are the work of Mr. Prendergast Parker, and the photographs of the microscopic specimens were made by Mr. H. George. I am also indebted to Mr. J. H. Montague for the loan of blocks illustrating surgical apparatus.

It is hoped that these additions, as well as improvements in printing, will further increase the usefulness and popularity of the book, 38,000 copies of which have now been published.

HARLEY STREET, W.
September, 1903.

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SURGERY;

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THEORY AND PRACTICE.

SECTION I.

General Pathology of Surgical Diseases.

INFLAMMATION.

Introduction.—Inflammation is the succession of changes which occurs in a living tissue when it is injured, provided that the injury is not of such a degree as at once to destroy its structure and vitality (Burdon Sanderson). It is a process combining degeneration and regeneration: on the one hand, a degeneration of cells and tissues, with a pathological exudation from the blood-vessels; and on the other, a regeneration of cells and tissues, with an absorption of the exudation (Ziegler). The degeneration is the first result of the injury, and varies in extent according to the kind of injury causing it, but is always harmful, and, so far, antagonistic to the regeneration, which is beneficial as tending to repair the results of the injury. Here the word "injury" includes all the *causes of inflammation* (see p. 10). If the cause quickly ceases to be operative, the inflammation may end by leaving the tissues apparently normal (see *Resolution*, p. 14), or by replacing degenerated cells and tissues by new ones derived especially from the fixed, previously-existing cells of the tissues, notably the connective-tissue cells, so that a *scar* is formed (see *Repair*, p. 7). If the cause be an active one, as when due to certain micro-organisms, there is such a rapid death of cells and tissues, and so much pathological exudation, that a creamy fluid, *pus*, in a cavity, *abscess*, is produced (see *Suppuration*, p. 19). Or if this process occurs on the surface of the skin or of a mucous membrane, it is spoken of as *ulceration* (see p. 29). When the injury, or the inflammation resulting from the injury, is very severe, there follows death of the tissue in masses, *gangrene of soft parts* (see *Gangrene*), and *necrosis of bone* (see *Bone*).

When the cause remains chronically active, degeneration and regeneration continue, the latter indeed going on to fibrous thickening in excess of that useful for repair, *chronic inflammation* (see p. 17).

A clean-cut wound, involving simply a division of the continuity of the tissues, is followed by very little cell and tissue degeneration and pathological exudation, so long as the causes of suppuration, especially the pyogenic micro-organisms, are prevented by the methods introduced by Lister (see *Wounds*) from becoming active. Thus the inflammation leading to the repair of such a wound is one mainly of cell and tissue regeneration.

Inflammations of a *special* character are set up by various *organisms* (see *Infective organisms*), the character varying with the organism.

Whilst inflammation includes regeneration by cell-proliferation, and whereas in chronic inflammation the cell-proliferation may continue beyond that useful for repair, yet the continuous cell-proliferation which characterises *new growths or tumours* proper, whether benign or malignant (see *Tumours*), is not at present regarded as similar to that of inflammation either in its causation or in its course. On the other hand, these new growths, by the products of excretion and of their degeneration, act as a cause of inflammation.

Naked-eye outlines of the process of inflammation.—Inflammation may occur anywhere in the body, and in whatever tissue or organ it occurs, whether on the surface of the skin or of a serous or mucous membrane, or in a deep organ, in a tissue vascular or non-vascular, hard or soft, the process is essentially the same.

Inflammation of the skin.—The affected area of skin shows, in comparison with that surrounding it, the four classical signs of inflammation: redness, swelling, heat and pain, to which may be added a fifth, *i.e.*, disturbance of function. The *redness* may be uniform and fade away into the natural colour of the surrounding skin; at first it disappears momentarily on pressure, but later may become mottled and of a deeper hue, and does not disappear when the finger presses on the skin. This redness is due to dilatation of the blood-vessels; hence it varies much, being marked where the skin is vascular and the vessels dilatable, as on the face and limbs, or the reverse, as on the hairy scalp and palm. The *increased heat* is due to the same cause, dilatation of the blood-vessels, so that the inflamed surface gives off more heat and feels hotter than is normal for that particular surface. The warmth of the skin surface thus more nearly approaches the heat of the blood in the large vessels, varying according to the vascularity. Normally the skin over the patella when exposed for a minute strikes cold to the palm of the hand, whilst a mere sensation of warmth is given off when the knee-joint is slightly inflamed, although no redness can be detected. On the other hand, the cheeks or ears may feel very

hot without being inflamed. However great the sensation of heat, a surface thermometer applied will always show a temperature less than that of the blood generally. The *swelling* is the result of pathological exudation (*œdema*); this may be displaced by the pressure of the finger, so that on relaxing the pressure a pit in the skin is left, which only slowly fills up. If a cut be made into inflamed skin, it will be seen to be full of bright red blood, mixed with œdematous fluid like blood serum. The veins leading from the part are fuller than normal, and the lymphatics are distended with lymph exudation as far as the lymphatic glands corresponding to the inflamed area. The *pain* felt by the patient is the result of irritation of nerve-ends by the pathological exudation, and varies with the natural sensitiveness of the part and with the degree of tension caused by the exudation, being much more marked in an inflamed tooth alveolus than on the neighbouring cheek, in the tense eyeball than in the loose scalp, in the finger than on the back of the hand, in the tense hip-joint than in the slack shoulder, in the firm groin than in the loose axilla. The patient's sensations are the result of the nerve excitation, and are likened to burning heat, although the part be not so hot as the blood in the larger vessels. The skin shows *disturbance of function* by becoming dry.

Inflammation of a mucous membrane.—The five cardinal signs are to be noted in varying degrees. An inflamed mucous membrane is redder or not according to its natural vascularity; thus the conjunctiva becomes markedly redder, but not so the very vascular mucous membrane of the nose. An increase in heat is but little noticeable. Swelling due to the collection of serous fluid in the submucous tissue is well marked, according as the mucosa is loosely attached or the reverse. Thus there is much more swelling in the pharynx or larynx than in the mouth or on the palate; on the turbinal bone than on the septum of the nose. The pain felt is more severe when the mucous membrane is closely attached, as on the nasal septum, palate, or gum. The chief pain results from the exudation extending into subjacent muscle, giving rise to pain of a cramping kind, as in the case of the pharynx in tonsillitis. The most marked sign of inflammation of a mucous membrane is the disturbance of function—at first a diminution, and then an excessive secretion of mucus mixed with pathological exudation.

Inflammation of a serous membrane.—The most marked of the five signs is the disturbance of function, along with an exudation that is in the main pathological. Redness is seen when the inflamed peritoneum is exposed; there is not, however, marked swelling, the exudation mainly escaping on the surface, and only infiltrating the sub-serous tissue to any extent in chronic inflammation. Pain is experienced of a stabbing kind, especially when the surfaces rub on one another in the early stages, not when they are separated by the exudation. The exudation is primarily an excessive secretion of the

normal lymph along with a variable addition of fibrinogen which forms fibrin.

Inflammation in a deep-seated organ.—Redness is only detected when an inflamed organ is cut into; the organ is then found to be excessively vascular. Swelling varies with the texture of the organ, according as it can become infiltrated by the exudation; thus lymphatic glands swell markedly, the testicle less, the eye very little, periosteum considerably, bone not at all. The pain, generally of an aching character, is severe whenever the organ cannot swell owing to an inelastic fibrous tissue framework, as in the case of the eye, testicle, and bone. Function will be disturbed according as the inflammation affects the various component parts of an organ, for example, in a gland according as the glandular elements or the connective-tissue framework is most affected.

Minute changes in inflammation.—The early changes are to be observed in translucent tissues, in which the normal circulation can be seen, such as the spread-out omentum of a dog or rabbit, the wing of a bat, the mesentery or tongue or web of a frog, the tail of a fish or newt. In a vascular area simple exposure to the air is sufficient to set up the phenomena of inflammation, which become more marked when it is treated with salt or some greater irritant. As distinguished from the normal circulation, the following changes occur:

FIG. 1.—Minute changes in inflammation. 1. Active hyperæmia. 2. Stasis. 3. Emigration of leucocytes. 4. Diapedesis of red blood corpuscles.

(*a*) *Stage of active hyperæmia.*—There is a dilatation first of the smaller arteries, then of the smaller veins, so that the blood stream is accelerated, the corpuscles being carried mainly in the axis of the vessel (Fig. 1, 1). The peripheral portion of the current in contact with the vessel wall consists of yellow serum, with here and there a white blood corpuscle or leucocyte travelling along more slowly. The position of the leucocyte in the periphery of the current is due to its lighter specific gravity; the peripheral current being slower than that in the axis of the lumen, owing to delay by friction with the vessel walls. Indeed, this may be considered as a normal result of dilatation, and need not be followed by the other phenomena of inflammation.

(*b*) *Stage of stasis.*—The current is next seen to slacken, first in the small veins, then in the capillaries and small arteries, next to oscillate backwards and forwards, and finally to come to a standstill. This stasis may persist, or corpuscles are seen to move on again, and the current to become re-established. During the slowing more

leucocytes appear in the periphery of the current, and they tend to adhere to the inner surface of the vessel-wall (*margination*), and, as the stasis becomes definite, to pass through the capillary wall. It is when stasis has definitely occurred that inflammation can be said to have commenced (Fig. 1, 2).

(*c*) *Emigration of leucocytes.*—The white blood corpuscles emigrate from the vessels; they immigrate into the surrounding tissue. An emigration of leucocytes is to a certain but as yet undetermined extent a normal phenomenon, but in the process of inflammation this occurs to an extent altogether beyond that which is physiological. It is the polynuclear leucocytes, which form about 70 per cent. of the total number of white corpuscles, that emigrate. After margination, or the falling out from the axial into the peripheral current and adhering to the vessel-wall, they begin to multiply by direct division and continue to do so after having passed through the vessel-wall. The passage through the wall of the capillary is carried out by the amœboid properties of the leucocytes, *i.e.*, it is an active movement of the leucocyte itself. Before the capillary wall has been markedly altered, the leucocytes pass through the cement substance between the endothelial cells. This may be compared to the film of a soap bubble, through which a fine object will pass, the film closing again behind. The leucocytes in passing through show pear and hour-glass shapes and amœboid movements, but afterwards resume a spherical shape in the tissue spaces outside the vessel-wall (Fig. 1, 3).

(*d*) *Diapedesis of the red blood corpuscles.*—Red corpuscles do not as a normal process pass through capillary walls. In the earlier and slighter stages of inflammation, red corpuscles are not seen outside the vessels; but as the capillary walls degenerate, some few may be carried out, and if the walls of the capillaries entirely give way, as they do in some forms of acute inflammation, there is free extravasation (*rhexis*) of blood into the surrounding tissues. The part played by the red corpuscle is entirely a passive one, depending upon the blood pressure on the one hand, and the giving way of the capillary wall on the other (Fig. 1, 4).

(*e*) *Pathological exudation.*—There takes place normally a passage of the fluid portion of the blood into the surrounding tissues and lymphatic spaces (*lymph*). This is partly owing to the secreting action of endothelial cells, and partly to a mere transudation depending upon blood pressure and osmosis. The exact relationship of these two factors in the formation of normal lymph is still an unsettled physiological matter, and *à fortiori* therefore as regards pathological exudation. The secretory activity of the capillary endothelium perhaps becomes stimulated by toxins acting as lymphagogues; the blood pressure in the capillaries is raised in consequence of the dilatation and the obstruction caused by the stasis; also the capillary wall in degenerating becomes more permeable. All three factors may be at present considered to act in bringing about the exudation;

in all probability the influence of each one is different in the varying forms of inflammation. The exudation in some cases resembles blood serum (*serous inflammation*), which by distending lymphatic spaces, and overflowing into the lymphatics, and infiltrating and soaking the tissues (*œdema*), causes them to swell. It may escape freely from a mucous or serous surface, or collect in a cavity formed by displacement of surrounding cells, as in a *blister*. In other cases the exudation resembles blood plasma, especially when the damage to the walls of the vessels is severe, coagulating and forming fibrin within the vessels as a *thrombus*, or filling the lymph spaces with semi-solid material, or collecting on a serous or mucous surface as a

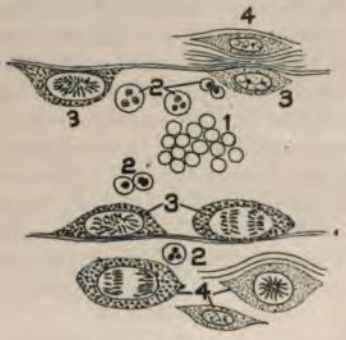

FIG. 2.—The wall of a blood-vessel, after Ziegler. Proliferation of endothelial and connective-tissue cells. 1. Red corpuscles. 2. White corpuscles, dividing directly to form leucocytes. 3. Endothelial cells lining blood-vessel with nuclei in various stages of karyokinesis. 4. Connective-tissue cells with nuclei undergoing karyokinetic changes outside the vessel-wall.

FIG. 3.—Proliferation of endothelial and connective-tissue cells to form fibroblasts (Ballance and Sherrington). 1. Red blood corpuscles in the lumen of a blood-vessel. 2. Endothelial cells lining a blood-vessel, and connective-tissue cells outside dividing and forming fibroblasts. 3. Dilatated capillaries.

false membrane. In the latter case, within the fibrinous network are seen broken-down white cells and blood platelets as well as red corpuscles, whilst the whole is soaked by the exudation like a wet sponge with water. This exudation may infiltrate and extend into previously healthy tissue, so obstructing the circulation and injuring nutrition as to cause further degeneration and inflammation. The pathological exudation, derived directly from the blood, becomes mixed, especially in glandular organs, with the secretion of the organ, owing to the latter being excited to an abnormal activity. At times it may contain so many red corpuscles as to be termed hæmorrhagic.

(*f*) *Changes in the fixed cells and tissues*. — The processes just described are all degenerative in character, and so also is the first change in the fixed cells and tissues; for the arrest of the

circulation and the exudation, after causing the walls of the capillaries to become turbid, affect the surrounding tissues. The fluid soaks among the connective-tissue fibres, causing them to swell and become loose, whilst the cells become vacuolated and break up into granules, which together with the fibres fall into the fluid and disappear.

But very soon in the slighter forms of inflammation, the fixed cells show signs of activity by undergoing karyokinetic changes in their nuclei and multiplying, and this marks the commencement of the process of regeneration. This change is more easily followed in a non-vascular area, such as the cornea, but is also to be observed in the peritoneal cavity or in the wall of a large blood-vessel obstructed by clot (Fig. 2).

If the centre of the cornea be injured, a turbidity follows around the injured spot, extending out to the circumcorneal zone of blood-vessels, which are seen to be dilated. Examining such a cornea in vertical sections, taken from animals at various times after an injury, it can be seen that from the dilated capillaries of the circumcorneal zone leucocytes immigrate into the corneal lymph spaces, and travel towards the injured centre. But meanwhile around the injured spot, in a steadily increasing degree, a change occurs in the cells forming the corneal corpuscles lying in the lymph spaces. These commence to proliferate by karyokinesis or indirect division of nuclei, as can be seen when the cornea is suitably stained —*e.g.*, by Fleming's osmic acid-safranin stain—so that the corneal spaces become filled by cells. Formerly there was much controversy as to the origin of the small round cells forming so-called granulation-tissue, and the cornea was one of the battlefields. In recent years this matter has approached a settlement. The leucocyte proper is derived from the polynuclear white blood corpuscle (Figs. 2 and 3). It multiplies directly both within and outside the capillary, and forms a small cell composed of only a film of protoplasm around a nucleus. It at first stains deeply, but this property gets less until the cell degenerates, breaks up, and disappears. The other small cells show an oval, at first less deeply staining nucleus surrounded by a varying amount of granular protoplasm, according to the age of the cell; they are descended from the endothelial and connective-tissue corpuscles by karyokinesis (Figs. 3 and 4), and if they again divide, they do so in the same way. They show two important phases of activity, (*a*) one in the direction of repair: hence they are called fibroblasts—a function now definitely denied to the descendant of the white blood corpuscle; (*b*) secondly, they act as phagocytes (Fig. 6), arresting the activity of the irritant, and aiding the process of absorption although this property, which originally belongs to the white corpuscle, is perhaps also retained by its descendant leucocyte.

(*g*) *Regeneration.*—This is found to begin some time after the

commencement of inflammation, eight hours at the earliest, and it is often not evident until after twenty-four or forty-eight hours. It is brought about by cells derived from the fixed cells of the tissues (Fig. 4). If a small glass chamber is inserted into the peritoneal cavity, cells descended by proliferation from endothelium enter the chamber and begin to form fibrous tissue. When a vessel is thrombosed (Fig. 3) the endothelial cells proliferate, and the young cells invade the blood-clot and replace it by fibrous tissue (Ballance and Sherrington). These fibroblasts are recognised by their oval nuclei, and by having a considerable although variable amount of granular protoplasm, which gives them the aspect of epithelial cells, and hence the term "epithelioid." The cells divide, the daughter cells are mononuclear, club- or pear-shaped, or oval, and then spindle-shaped, both cell and nucleus gradually elongating. Next a fibrillar change takes place, either in the fluid secreted around itself by the cell, or in the actual protoplasm of the cell. This may go on until the whole cell and nucleus is transformed into fibrous tissue, or the elongated nucleus persists with a little protoplasm around as a connective-tissue corpuscle. Some have traced fibroblasts to cells emigrating from the vessels. Such cells are doubtless derived from the endothelium lining the vessel, although possibly a fibroblast descending from a connective-tissue cell may wander into the circulation, and later pass out again.

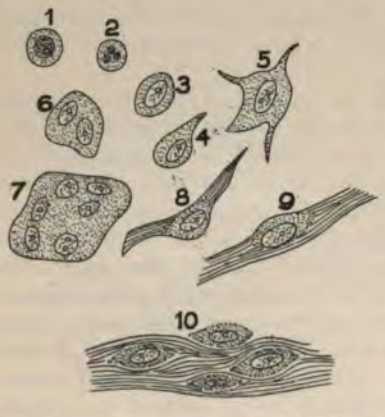

FIG. 4. — Regeneration by fibroblasts. 1. Mononuclear leucocyte. 2. Multinuclear leucocyte. 3. Endothelial or connective-tissue fixed cell becoming a fibroblast. 4. A pear-shaped cell. 5. A stellate cell. 6. A cell with two nuclei. 7. A multinucleated giant cell. 8. A spindle cell, its ends becoming fibrillated. 9 and 10. Fibrous tissue formation, leaving a nucleus and some protoplasm of the fibroblast as a connective-tissue cell.

A surface lesion becomes covered in by proliferation of epithelium in the case of skin or mucous membrane, or of endothelium in the case of serous membrane. Epithelial cells proliferate by karyokinesis to form new cells of a similar character.

(*h*) *Restoration of circulation* (Fig. 5).—The circulation, arrested by stasis, is restored by the formation of new blood-vessels round and past the obstructed point, and in the regenerating tissue. This occurs by budding from previously existing capillaries, by which means new loops are formed. Quite early endothelial cells multiply and sprout out from the vessel to reach across and meet a similar bud, or to

join another capillary, the sprout being composed of granular protoplasm and multiplying nuclei. Then this loop differentiates into endothelial cells, which become arranged as a capillary wall, around a hollow channel through which blood begins to flow, the whole process being similar to that which takes place in the embryo.

(*i*) *Absorption.*—The *fluid exudation*, along with the products of degeneration of cells and tissues, and also the leucocytes, tends to be removed. This is chiefly brought about by the restoration of the circulation, aided by the activity of cells, the agent producing the inflammation being no longer active. The fluid portion of the exudation passes away by the lymphatics and veins, chiefly owing to the vis a tergo of the blood stream. The lymph flowing in the lymphatics contains unorganised débris of cells and fibrin, also some still organised leucocytes, which are carried up to the lymphatic

FIG. 5.—New formation of capillaries by sprouts composed of granular protoplasm and multiplying nuclei. 1. Multiplication of endothelial cells in the wall of a capillary. 2. Growing outwards. 3. Forming a protoplasmic loop on the capillary. 4. Joining another capillary. 5. Differentiation of the protoplasm and nuclei to form a hollow tube.

glands to be destroyed there. The endothelium aids absorption by the normal secretion of lymph.

Phagocytosis (Fig. 6).—Cells derived from connective tissue and endothelium, called macrophages, take up cell débris, pigment, etc., and digest it; bacteria are thus swallowed, lose their staining properties, die, and disappear. Some cells which act in this way are held to be leucocytes, and called microphages. These macrophages and microphages, after digesting and rendering harmless organisms and débris, in turn degenerate, break up, and pass off with the fluid. But macrophages, after taking up material, may still serve as fibroblasts, as proved, when they take up pigment, by finding the pigment afterwards in the fibrous tissue. A microphage when it takes up pigment carries it to a lymphatic gland, where the cell breaks down and deposits its pigment, as seen after tattooing.

Proteolysis.—As a further aid to absorption, a portion of the degenerated material may be rendered soluble by a process of proteolysis, the proteolytic ferment being formed specially by the

leucocytes. This is a process of extra-cellular digestion, as compared with the intra-cellular digestion by phagocytes.

Causation of inflammation.—Theories.—In the present state of knowledge it is not wise to let theories of inflammation influence the mind lest it colour practice. Surgeons formerly spoke much of "Nature," and of the "vis medicatrix naturæ" of some unseen force, which acting by itself tended to cut short inflammation and promote repair, or "to antagonise or remove irritants and prepare the way for reparation" (Adami), or "a phagocytic reaction of the organism against irritants" (Metchnikoff). Surgery has advanced by actively interfering with, either preventing or removing, the causes of inflammation.

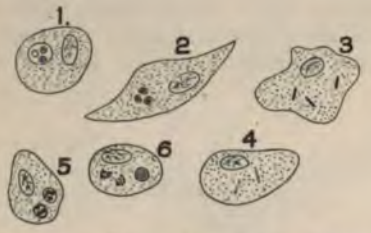

FIG. 6. — Phagocytosis (after Ruffer). 1. Macrophage, a cell derived from connective-tissue and endothelium which has included a polynuclear leucocyte. 2. Leucocyte disappearing in the macrophage, only nuclei seen. 3. Macrophage which has included bacilli. 4. "Bacilli fading," losing staining properties. 5. Macrophage, which has included red blood corpuscles. 6. Red corpuscles disappearing, only hæmoglobin masses seen.

Anything injurious to the cells and tissues of the body, if of sufficient intensity, can provoke inflammation. Generally, the injury comes from without, is *ectogenous*, a mechanical, thermic, electrical or chemical irritant. This last is the most frequent cause, being produced by organisms which have in their substance, or which excrete soluble chemical poisons or toxins, causing widespread cell degeneration and destruction. These organisms being parasites, and so living and multiplying in the fluids of the body, the poison is continually formed afresh.

Inflammation also arises within the body, is *endogenous*. Thus cell-degeneration takes place on an extensive scale when a part is deprived of its circulation. The products of abnormal metabolism set up inflammation, *e.g.*, in gout. Tumours excrete from their cells harmful products, and also their cells degenerate, especially when they fungate. Another form of inflammation is by *metastasis*, the excitants being carried onwards by the blood or lymph stream, to set up inflammation elsewhere, as, for example, in passing out through the kidney.

Inflammation is *independent of the control of the nervous system*. When it occurs in a part in which there is primary hyperæmia, whether from vaso-dilatation, as in a rabbit's ear after division of the cervical sympathetic, or in the case of a limb with venous congestion, it is apt to be acute. But recovery from such hyperæmia may occur without any of the changes above described. The first characteristic feature of inflammation is *stasis*. This is brought

about by degenerative changes in the vessel-wall, and as a result, there is increased resistance to the blood-current. The increase of friction between the blood-stream and the vessel-wall disturbs the equilibrium normally existing, and so the blood stream first becomes slower, and then is arrested. The slowing of the stream favours margination of the white cells, which then adhere to the vessel-wall by their processes, or there is an increased adhesiveness of the vessel-wall which causes the white cells to stick. The degeneration in the vessel-wall results also in a greater penetrability. Thus, inflammation may be said to *commence in the vessel-wall*, and when the causes of inflammation are brought by the blood, *e.g.*, in the case of gout as above mentioned, it is conceivable that inflammation may be strictly limited to the vessel-walls, but generally, especially in the case of the arterioles and capillaries, the surrounding tissue becomes involved to some extent.

Further, in inflammation the tissues around may influence the vessel-wall; a relaxation by degeneration of connective tissue would thus allow a capillary to dilate and so favour slowing and stasis.

The *stasis* which marks the commencement of inflammation ends in *thrombosis* by the formation of a blood-clot, the clotting being started by the breaking up of white blood corpuscles from contact with the roughened walls of the vessel.

The adhesion of the white corpuscles to the vessel-wall and their emigration into the tissues may be considered to be due to chemical products liberated by the commencing degeneration of the endothelial cells, the chemical products attracting the leucocytes, *positive chemiotaxis*. In some cases leucocytes are repelled, *negative chemiotaxis*.

The immediate or exciting causes of inflammation.—These must be regarded as in the main chemical. A mechanical injury, as a cut or bruise, the rapid abstraction of water from the tissues by heat or cold or electricity, actually destroys some vessels, so that the circulation is thereby arrested. But chemical irritants are formed from these cells and tissues, thus mechanically injured. Croton-oil or mustard applied to the skin, or mercury or turpentine injected into the connective tissue, cause degeneration and death of the cells and tissues with which they actually come in contact. These cells in dying liberate substances which cause further degeneration and inflammation, by acting as unorganised ferments or enzymes. Now all causes such as the above, quickly cease to act and allow regeneration to start. Likewise a foreign body which does not introduce with itself organisms, sets up only a very limited inflammation merely displacing tissue and giving rise to some friction. The chief exciting causes of inflammation then are the *chemical products of the action of organisms*, for by the activity and growth of organisms fresh cells are continually degenerating and fresh toxic substances are being produced.

The predisposing causes of inflammation, so called, are not to be distinguished from the exciting causes, since they act in the same way, tending to cause cell and tissue degeneration, by impairing the quality of the blood generally or the quantity of the supply to the affected part. The quality of the blood is impaired by deviation from normal metabolism, by insufficient or improper food or air, or by morbid states such as anæmia, alcoholism, Bright's disease, diabetes, gout, syphilis, the tuberculous diathesis, or by poisoning by lead, mercury or phosphorus. The quantity of blood flowing through the part is impaired by a feeble heart's action, or by arterial or venous obstruction. Disease or injury of a nerve centre or nerve trunk disturbs the nervous control of the circulation and the normal functions of the part, so that it is the more easily attacked by inflammation.

Symptoms of inflammation.—Fever. — The *constitutional symptoms of inflammation* may be summed up as those of *fever*. There is a rise of temperature—often preceded by chilliness or even by a distinct rigor, a quickened pulse, dry skin, furred tongue, loss of appetite, constipation, scanty and high-coloured urine, headache, perhaps delirium, and a general feeling of malaise. When the inflammation is slight there may be no fever; but when it is at all intense, or occurs in an important part, the fever is generally considerable, especially in infective inflammations. Inflammatory fever has been divided into the sthenic, asthenic, and the irritative or nervous. In the *sthenic* all the symptoms are acute, the temperature is high (104° or 105°), and the pulse full, strong, and bounding. In the *asthenic* the symptoms assume what is called a typhoid character; the temperature falls, the tongue becomes brown and dry, the lips and teeth are covered with sordes, and the pulse is quick, soft, and feeble. In the *irritative* there is in addition to either of the above set of symptoms, delirium, violent in the one case, or low and muttering in the other, and a state of general nervous excitability.

The symptoms constituting *fever* indicate a complex general disturbance of metabolism. The *rise in the temperature* of the body points to a disturbance of the normal equilibrium between the production and the loss of heat. Heat is produced in excess owing to increased oxidation, as shown by the greater amount of urea and other nitrogenous substances excreted in the urine, and by the rise in the quantity of carbonic acid expired; also by the loss of body-weight and the using up of fat—not that this increased oxidation ever reaches in amount that brought about by muscular exertion. With the increased production of heat there is not a corresponding loss. Early in a fever, when the vessels are constricted and the skin pale, there may be no loss of heat above the normal, even less; during the height of the fever, when the skin is hot, there is an increased loss of heat, but not proportionate to the increased production. It may

be difficult to bring down the patient's temperature to the normal level even by applying cold. The chilliness or distinct *rigor* is the result of the contraction of the peripheral arteries, so that the amount of blood, therefore the amount of heat reaching the skin, is less than normal, by which a reflex involuntary excitation of muscles is set up. Later the skin becomes hot, showing an excitation of vaso-dilator nerves, or a paralysis of vaso-constrictors; or part of the skin may be too cold and part too hot, showing a disturbance in the vaso-motor regulation. The skin is *dry* from the arrested secretion of sweat coupled with the vaso-constriction. At other times there is an excessive secretion, especially as the temperature falls; or at night a "hectic" fever, indicating a disturbance of the normal regulation of secretion of sweat.

There is diminished secretion in glandular organs. Deficiency of saliva causes the mouth and lips to become dry, and the saprophytic organisms in the mouth, no longer kept down by the saliva, develop freely, and form with epithelial débris the *fur on the tongue*. A diminished secretion by the stomach leads to *loss of appetite* and inability to digest; the failure of intestinal secretion to *constipation;* whilst the dry mouth and the increased loss of fluid by evaporation give rise to *thirst*.

Similar influences on the kidney result in the *scanty amount of urine*, of *high colour*, from the excess of the nitrogenous excreta. The *pulse is increased in frequency*, the control of the heart by the vagus being disturbed. At first full, the *pulse tension* lessens as the force of the heart-muscle becomes weakened by the poisonous products of the inflammation. This may become so marked as to be the immediate cause of death. A similar effect on the muscles generally causes *debility* and *prostration*. Toxic substances act on the nervous system in the same way that the products of fatigue from muscular exertion do, causing, if slight, *malaise* or *headache*, if severe, *disturbances of consciousness, delirium, trembling* and *twitching movements* of the hands, or *convulsions* in children.

Fever is not caused by one chemical substance, but by many, all derived from cell degeneration. The transfusion of blood from one animal to another gives rise to fever, as does also the injection of various products of animal and vegetable decomposition. But fever is chiefly due to the destruction of cells brought about by growing organisms and by the substances they excrete. How far fever results from a direct influence on the nervous system is doubtful. That it possibly results in this way is shown by the fever which occurs in epileptic attacks, from emotional excitement, in progressive paralysis, fright, the passing of a catheter, etc. Experimentally, fever can be caused by puncture or excitation of the central nervous system. But whatever this nervous influence amounts to, it is small as compared with that of the chemical products of cell and tissue degeneration resulting from the infective organisms.

Termination of inflammation by resolution.—The symptoms subside and the functions become normal, whilst the inflamed part, even on microscopical examination, may show no variation from the normal structure. This termination entails first the cessation of the activity of the cause, and, for the change to be permanent, its removal from the body and a return to the normal circulation of blood through the affected part, both as regards quality and the regulation of the quantity. Organisms may be killed and digested by cells, or rendered inocuous and excreted. A temporary obstruction in a mucous tract may pass on and so relieve the retention behind it. Or the cause may be removed by surgical means, a foreign body extracted, organisms destroyed by antiseptics, the tension due to retained fluid relieved by incision. The cause being removed, the circulation is restored by the formation of new vessels to take the place of those blocked by stasis, toxins in the blood are oxidised and excreted, and thus the quality of the blood returns to the normal, and it is again properly regulated as to quantity by the vaso-motor mechanism.

Treatment of acute inflammation.—From the foregoing considerations it is clear that treatment must be directed to removing, or at least rendering harmless, the cause, and to favouring the restoration of the normal blood-supply. Whilst this is taking place injurious symptoms are counteracted, by which means the patient's general condition is improved, and the return to the normal favoured. Treatment must aim at preventing acute inflammation from being followed by chronic inflammation, suppuration, ulceration or gangrene.

(A) **Local remedies.**—*The removal of the cause.*—The measures for preventing organisms from setting up inflammation, also their destruction and removal, will be dealt with under the *Treatment of wounds*. The relief of tension and the removal of foreign bodies, etc., will be described in numerous places.

Measures favouring the return of the normal blood-supply.—*Rest.*—This is one of the most important means we possess in the treatment of surgical inflammation. It should be complete if possible; not only rest of the affected part and of the general functions of the body, but also of the mind. Premature movement whilst regeneration is going on may cause destruction of newly-formed tissue and further inflammation.

Elevation of the part affords relief by diminishing the excessive arterial supply until the vessel-walls cease to be dilated and regain their normal tonus, whilst gravity favours the venous return, and the draining off by the lymphatics of the inflammatory exudation. Thus an inflamed hand should be placed in a sling, an inflamed foot raised on a pillow, etc.

Cold is a powerful agent in controlling acute inflammation, but is a remedy which requires cautious and seasonable application.

It acts by causing contraction of the small arteries, and consequently diminishes the flow of blood to the part. Perhaps it likewise checks the excessive emigration of leucocytes by limiting their amœboid movements. Cold, however, when intense, lowers the vitality of the tissues, and itself promotes stasis, and, as exemplified by frost-bite, destroys by arresting the blood flow. Its most important service is inhibitory in the earlier stages of inflammation; later, when inflammation is fully established, it may do mischief. If used, its application should be continuous; when intermittent, cold tends to increase inflammation by the dilatation of the vessels and the slowing of the current, which follows as a reaction to the contraction. Generally, it should not be applied where the circulation locally is poor, or in old people or young children, or to a vascular part except when it gives relief to the patient. It is best applied in the form of an ice bag, small lumps of ice wrapped in lint and covered by oiled silk, or ice-cold water passed through coils of lead tubing (Leiter's tubes).

Heat and moisture act by causing a general dilatation of the smaller vessels and a free flow of fresh blood through the part into the veins and lymphatics. Their application is especially useful when inflammation has become fully established and suppuration threatens. Under the latter circumstance the process becomes localised and the abscess tends to come to the surface. It is best applied as boric acid fomentations; lint is soaked in a boiling-hot saturated solution of boric acid, picked up with forceps and dropped into a clean (or better sterilised), dry, warm towel, which is now twisted up tightly so as to wring the lint out as dry as possible. It is then quickly applied, covered with oiled silk, and over this a layer of wool to keep in the heat. Neither perchloride of mercury nor carbolic acid should ever be used in this way: not only may they be absorbed, but the perchloride causes pustular eruptions, and the carbolic acid gangrene, especially of the fingers. Dry heat may be applied by wool heated in an oven, by an electric bell lamp held over the part, or by Leiter's tubes through which hot water is passed. Poultices of linseed-meal, bread, or charcoal, should never be used for surgical purposes; wherever there is an open wound they promote decomposition.

Local blood-letting relieves the vessels of the inflamed part, so removing tension which prevents the return of the proper circulation. This may be done by means of leeches, wet cupping, punctures, and short incisions. Leeches may be applied directly over a part, such as the knee, or at some distance, *e.g.*, behind the ear to relieve an inflamed eye. Further, hæmorrhage may be encouraged by applying a fomentation. A leech should never be used again, for fear of infection. Wet cupping may be used, the punctures being made by a tenotome or by a spring scarificator, which being set to cut about an eighth of an inch deep, is held

firmly on the skin and the trigger pulled, allowing a number of knives to be protruded and then withdrawn. A cupping glass is of tough material with a smooth rounded rim. The skin is moistened, also the rim of the glass, then the air in the glass is heated by holding it over a spirit-lamp, or by rinsing it out with spirit or by putting in a strip of filter paper saturated with spirit, then igniting and applying, while still flaming, over the punctures. There must be no excess of spirit to drop on the skin. The cup should be applied just firmly enough to promote a vacuum; if too firmly, pain is caused and the flow of blood impeded. Multiple punctures or short incisions are useful in some forms of inflammation, such as phlegmonous erysipelas. They should be made in the long axis of the limb or in the lines of the folds of skin, avoiding important structures, superficial veins, etc. Care must be taken that such punctures are not re-infected from without.

Astringents act by constricting the blood-vessels, and are especially useful in inflammations of the mucous membrane of the mouth, nose, urethra, and conjunctiva.

(B) **Constitutional remedies.**—Like the local, these should be used according to the intensity, nature and situation of the inflammation, and the type of the constitutional disturbance. In an ordinary case of simple inflammation, beyond a brisk purge, subsequent regulation of the bowels and secretions by salines, and restricting the diet, no special constitutional treatment is required. But when the fever is high, the patient young and vigorous, and the pulse rapid, full, and strong—in short, where the fever is of the sthenic type, antiphlogistic or lowering treatment should be adopted. Where, on the other hand, the patient is weakly or old, or broken down in constitution, and the fever is of a low or asthenic type, a stimulating plan of treatment will be required.

Antiphlogistic treatment may be considered under the heads of diet and drugs. General blood-letting is now rarely employed.

The *diet* should be restricted to milk, weak beef-tea, barley water, arrowroot, and the like.

Drugs.—Purgatives determine the flow of blood to the intestines, and so relieve the inflamed part. They are generally employed as a brisk purge at the onset of the inflammation, *e.g.*, in gonorrhœa and orchitis, in which they are of considerable benefit by removing pelvic congestion. In inflammations of the intestine aperients must be used with caution. Diaphoretics and diuretics relieve the distended vessels, the former by determining the flow of blood to the skin, the latter to the kidneys. They are not often employed in surgical inflammations. Aconite in small doses, frequently repeated, reduces the frequency and force of the heart's action, and is of much service in acute tonsilitis. Antimony was formerly much employed, and is still used in inflamed testicle. Mercury in combination with opium was once in much favour

and was thought to have a controlling action on the inflammation. It is seldom given at the present day, except in syphilitic inflammation, and as a purgative in the form of calomel at the commencement of other inflammations. Opium, however, is frequently used to relieve pain, and it also seems to have some action in controlling the inflammation. It may be given by the mouth, or in the form of morphine as a subcutaneous injection by which constipation is avoided. Quinine, salicylic acid, and antipyrin are sometimes employed when the temperature is high, as is colchicum in gout, potash and salicylate of soda in rheumatism, perchloride of iron in erysipelas, and morphia, nepenthe, hyoscyamus, bromide of potassium, sulphonal, trional, chlorotone, and chloral when there is want of sleep.

In *asthenic inflammation* the *stimulating plan* of treatment should be adopted. It may be considered under the heads of diet, drugs, and stimulants. The *diet* should consist of essence of beef, milk, eggs, milk-puddings, oysters, strong soup, plasmon, and of white fish and minced chops when solid food can be retained. Of *drugs*, ammonia and bark, or quinine and iron will generally be found of most service ; whilst *stimulants* in the form of brandy, the brandy-and-egg mixture, port-wine, champagne, or any other that the patient has been accustomed to take, should be given in divided and measured doses at stated intervals. Stimulants increase the force of the heart's action, and so drive the blood through the inflamed part, and maintain the circulation till the crisis has been tided over. The indications for their use are a feeble and frequent pulse, a high temperature, a dry and brown tongue, and general signs of prostration.

Chronic inflammation.—In chronic inflammation the process is essentially the same as in acute, but the vessels remain dilated for a longer period, emigration of leucocytes continues, whilst simultaneously proliferation of the fixed cells goes on, often to an excess beyond that suitable for repair, *e.g.*, the walls of the blood-vessels are thickened, especially their inner coat. The causation is likewise similar. The exciting cause acts less severely, but more continuously or repeatedly, *e.g.*, organisms continue to develop and remain at the site of infection, preventing healing, also keeping up a production of toxins, and so there is a chronic intoxication unfavourable to nutrition, or there is some persistent error in metabolism. The so-called predisposing causes may be placed under one of these two headings, viz., the continuous action of organisms, especially in tuberculosis, perhaps also in syphilis and rheumatism, or a disturbance in cell nutrition brought about by passive congestion, gout, etc. Secondary influences may play a part ; thus a trivial injury in a rheumatic subject, absence of rest, tension in the synovial membrane of a joint, etc., may keep up inflammation for months or years.

Symptoms.—Of the local signs redness may be absent, or, if present, may be of a dusky hue from venous congestion rather than from arterial, whilst the part is often discoloured by pigmentation derived from red blood corpuscles, which have broken down after diapedesis. The pain is less severe than in the acute form, often of a dull aching character, but increased to a marked degree by pressure. It is also sometimes worse at night. The part is generally slightly hotter than normal, but at times no increased heat is apparent. Swelling is a marked sign, resulting partly from inflammatory exudation, partly from excessive cell proliferation and the resulting fibrous tissue. Constitutionally, the patient's health is often feeble; he is anæmic, or has tuberculous, gouty, rheumatic or syphilitic symptoms. At times there may be some fever. Chronic inflammation may terminate in *resolution*, leave behind permanent *fibrous thickening*, or be followed by *suppuration* and *ulceration*.

Treatment.—The indications are: To remove the cause and all secondary sources of irritation; to promote the absorption of inflammatory products; and to re-establish the normal nutrition of the damaged tissues. Constitutionally, an endeavour should be made to improve the general health by a careful dietary, regulation of the bowels and urine, the administration of stimulants and tonics. In the tuberculous, cod-liver oil; in the syphilitic, mercury or iodide of potassium; in the gouty, colchicum; and in the rheumatic, potash salts, salicylates, guaiacum, and sulphur are especially indicated. Residence at the seaside or in the country, a course at some spa suitable to the diathesis, or a sea-voyage, may be enjoined.

Locally the means at our command after the removal of the cause, if possible, such as organisms, foreign bodies, dead bone, are—1, Rest; 2, Counter-irritation by mustard, cantharides, iodine or other stimulating liniments; 3, Friction, shampooing with hot water or hot sea-water, massage; 4, Inunctions of mercury or iodide of potassium; 5, Pressure by careful bandaging over wool, or by an elastic bandage (Martin's), strapping with the compound mercury ointment spread on chamois leather and cut into strips (Scott's dressing); 6, Setons are now seldom used, unless it be just within the margin of the hair or the temple for chronic eye inflammation, at the nape of the neck for migraine. The skin is shaved and cleaned, a little nitrous-oxide gas given, a fold of skin pinched up and transfixed by a tenotome, along the blade of which a probe is passed with its eye threaded with a large-sized silk thread; this is pulled through and the ends tied. Infective complications must be prevented by cleanliness and dressing; the silk thread is periodically moved. Formerly unguentum sabinæ was applied to increase the effect. 7. Issues were formed by inserting a foreign body, such as a large bead, into the subcutaneous tissue, but are not now used. 8. The actual cautery. Streaks or dots are made with the benzin cautery under nitrous-oxide anæsthesia over chronically inflamed

joints; the burning should not go through all the thickness of the skin. But this method is mainly confined to veterinary surgery. 9. Acupuncture. Fine, highly polished steel needles are passed in whilst deftly rotating the needle between the thumb and fingers. It has been most widely used in the East, and is so still among native practitioners, the needles being often passed deeply, *e.g.*, into the liver. It has proved of service in chronic muscular rheumatism.

SUPPURATION AND ULCERATION.

We have already seen that the inflammatory process involves an emigration of leucocytes from the blood, together with a pathological exudation, which is followed by proliferation of tissue cells in the direction of repair. In the presence of active pyogenic organisms and their toxins the emigration of leucocytes becomes excessive, whilst the proliferation which produces fibroblasts, and active phagocytes capable of destroying organisms, is checked and held back. The leucocytes die and liberate a proteolytic ferment which renders much of the products of degeneration soluble, whilst for the time being the cells proliferated by the tissue are killed. Only when relieved by removal of the toxins and dead products can the fibroblasts gradually get the upper hand and start healing. Suppuration, then, is the degenerating phase of the inflammatory process carrying cell and tissue destruction to an excess before the regenerating phase can overcome it. Suppuration occurs (1) In the substance of tissues and organs, where it may be (*a*) circumscribed or limited in extent, forming an abscess; (*b*) diffused, more or less widely, either uniformly, or exhibiting numerous foci constituting small abscesses, which may afterwards fuse; (2) In the serous or mucous lining of a cavity, the products collecting in the cavity to form an empyema, which may extend to neighbouring tissues, or discharge on the surface of the skin or into a mucous tract. (3) On the free surface of the skin or mucous membrane, the discharge escaping being known as purulent "catarrhal" exudation, when the superficial layers of epithelium are involved, or as ulceration when the process extends through to the deeper parts.

(A) **Circumscribed suppuration or abscess.**—An abscess may be described as a circumscribed collection of pus, the result of inflammation. It may be acute or chronic.

Acute abscess.—Studying the formation of an abscess in superficial tissues, the inflamed part is found hot, red, swollen, and painful. The swelling, at first more or less diffuse, becomes pronounced at one spot; here the redness is more intense, and the pain has a throbbing character, for the vessels are so dilated and the nerves so sensitive that each pulse-wave can be felt. When pressing lightly with the fingers upon this spot there is acute tenderness, the skin pits owing to superficial œdema, and a sensation of displacing fluid,

fluctuation, is perceived beneath the skin, when pressure is made alternately with two fingers. If left untreated the abscess wall yields to the tension within in the direction of least resistance, *i.e.*, generally towards the free surface of the skin, or towards a mucous canal or a serous cavity, *e.g.*, a joint, or the pus may become diffused into the subcutaneous or intermuscular connective tissue. In the case of a superficial abscess, the centre of the fluctuating area becomes more prominent, almost conical, with the surface a dusky red and glazed. The abscess is said now to *point*. The skin will soon become bluish-black ; it will ulcerate or slough, and bursting of the abscess with discharge of pus will ensue. For within the abscess the fluid is under a tension, which approaches that of the blood in the dilated arteries of the inflamed part, whilst the thin-walled veins and lymphatics are pressed to one side and compressed, so that absorption cannot occur. Moreover, when gas-forming organisms are present, the gas production increases the tension within the abscess walls.

The minute changes concerned in this process are briefly as follows (see Figs. 7, 8) :—The excess of emigrated leucocytes along with a smaller number of cells resulting from the original tissue cells, aggregate at the focus of inflammation, around the micro-organisms which have settled down and multiplied there. These cells and the neighbouring tissues undergo degeneration and death as the result of the toxic products of the organisms. The cell and tissue elements may first become swollen by being infiltrated by the fibrogenous exudation, which then coagulates into fibrin. This degeneration and death, accompanied by infiltration and formation of fibrin, is called *coagulation necrosis*. Following upon this necrosis, there is softening and liquefaction by means of a proteolytic ferment resulting from the leucocytes, so that the centre of the inflammation is occupied by a fluid in which the dead leucocytes and connective tissue cells float. The latter are known as *pus corpuscles*, the fluid as *liquor puris*. Around this focus inflammation continues, with emigration and exudation from the blood-vessels and proliferation of tissue cells. Either the degeneration advances and more dead cells fall off as pus corpuscles into the fluid and the abscess cavity enlarges, or an equilibrium is reached, and then proliferation and regeneration get the upper hand, and the abscess wall comes to be composed of fibroblasts, among which new blood-vessels are developed, forming a zone of vascular granulation tissue, which is called the *pyogenic zone*. It is a *pyogenic zone* if the suppuration is extending, or whilst the tendency to degeneration and pus formation on the one hand, and of the tendency to repair on the other, is in equilibrium. As soon as regeneration gains the upper hand the *pyogenic zone* becomes the *fibroblastic zone*, young vascular fibrous tissue forming in it from without inwards, and gradually changing into definite scar tissue.

Characters of pus.—Pus from an acute abscess is typically a thick, creamy, opaque, yellowish-white, slightly alkaline fluid, with a faintish sickly smell, saltish taste, and specific gravity of about 1030.

Dilated vessels with increased flow
Dilated vessels with retarded flow and escape of Leucocytes into connective tissue.
Vessels with dense infiltration of the connective tissue with Leucocytes at the focus of the inflammation.

FIG. 7.—Diagram of the minute changes in an inflammatory focus.

Under the microscope pus corpuscles, granular material, and fat-globules are seen floating in a fluid. The corpuscles are mainly

FIG. 8.—Diagrammatic representation of the minute changes in the formation and healing of an abscess. The upper half shows abscess enlarging; the lower half abscess healing.

polynuclear leucocytes, the two or three nuclei being more clearly seen on the addition of acetic acid, the rest of their substance being composed of granules, fat-globules, and vacuoles. Most are dead

and swollen by imbibition of fluid. In an acute abscess some cells are still alive, and show amœboid movements on a warm stage. In size, therefore, the dead pus corpuscle is rather larger than the living leucocyte or white blood corpuscle. Whilst varying much, it has an average diameter of $\frac{1}{2500}$ in., or 10 μ.

The liquor puris contains albumen, which coagulates on boiling, and salts, especially chloride of sodium. It does not generally coagulate spontaneously, the fibrinogen of the exudation having already formed fibrin; but when an acute abscess is opened early, some spontaneous coagulation occurs on standing.

Various organisms, especially the pyogenic organisms, are present in pus. If allowed to stand or remain undrained in an abscess cavity after opening, saprophytes grow in it freely, especially the bacillus pyocyaneus, giving rise to a blue colour.

Varieties of pus.—Pus is spoken of as sanious when it contains blood; curdy when portions of coagulated fibrin float in it; ichorous or serous when thin, and consisting largely of serum; muco-purulent when mixed with mucus from a gland or surface.

The cause of suppuration and abscess.—Any cause of acute inflammation leading to excess of degeneration promoted by the persistent action of the irritant and the lack of regeneration on the part of the patient is also a cause of suppuration. Practically suppuration is due to the presence in the tissues of one or more of the pyogenic organisms in such an active state that their attack cannot be sufficiently resisted. The staphylococcus and streptococcus pyogenes are the chief organisms, especially the staphylococcus in a circumscribed abscess, the streptococcus in diffuse phlegmonous suppuration. Both also cause muco-purulent inflammations and ulcerations, as does, too, the gonococcus. When the suppuration is near the intestinal tract, the action of pyogenic organisms is complicated by the presence of gas-forming organisms—the bacillus coli communis and its allies. The diplococcus pneumoniæ, or pneumococcus, gives rise to suppuration, especially on serous surfaces, such as the pleura and large joints. Tuberculosis, also syphilis and actinomycosis, give rise to inflammation, readily going on to suppuration.

Experimentally, suppuration has been set up without organisms by inflammation starting with excessive cell and tissue destruction. Sterilised cultures of various bacteria (including those saprophytes growing in decomposing pus, such as the bacillus pyocyaneus), containing bacteria-protein, also quicksilver, turpentine, croton-oil, petroleum, and nitrate of silver, when injected aseptically, cause a limited abscess, which does not spread locally nor form metastases; the pus contained is free from organisms, is sterile, and not virulent when animals are inoculated with it.

The *constitutional symptoms of an acute abscess* are at first those of inflammation; generally a chill or rigor is experienced at the time when throbbing pain is first felt. The pain usually gets less when

suppuration is fully established. Although the abscess may be rapidly extending, yet the patient often feels temporarily quite relieved owing to the cessation of tension. The absorption from the cavity of special toxins sets up an increased formation of white blood cells, (*leucocytosis*), so that the number of white cells, especially the polynuclear cells, normally varying between 5,000 to 10,000 per 1 cubic mm., may increase to 20,000 or more.

Diagnosis of suppuration.—The formation of an acute abscess is indicated by the severity of the local signs of inflammation—the throbbing pain, the local tenderness on pressure, the pitting, then the appearance of fluctuation, and later that of pointing. Deep-seated suppuration is often difficult to detect; but superficial œdema, subcuticular mottling, or deep-seated resistance, should lead the surgeon to suspect its occurrence. In such a case the presence of leucocytosis may prove of value as an aid to diagnosis; other causes of leucocytosis being discounted, such as hæmorrhage, pneumonia, diphtheria, scarlet fever. For instance, leucocytosis may appear in acute appendicitis, going on to suppuration, and in typhoid fever when perforation has occurred. The diagnosis between deep-seated abscess and aneurysm will be referred to under the latter.

Termination of suppuration.—1. Exceptionally, under favourable circumstances and when limited, an acute abscess may *spontaneously burst*, the walls then fall together, and become lined by granulation tissue, which forms fibrous tissue, so that the cavity contracts and fills up until only a scar remains. Generally some complication ensues, thus:—

2. The abscess cavity may form a *sinus or fistula* (see p. 26).

3. Retention and decomposition of the pus may keep up a continuous absorption of toxins, *septic intoxication*, *toxinæmia*, or *sapræmia*, or the organisms penetrate the abscess wall and enter the blood, *septicæmia*, so that metastatic abscesses arise, *pyæmia* (see *Infective Processes*).

4. The suppuration may *spread locally* until it involves some important part—the peritoneal cavity, a joint, or a large vessel from which hæmorrhage may then occur.

Treatment.—To relieve inflammation threatening suppuration a boric acid fomentation sprinkled with tincture of opium, or a poppy-head fomentation, may be applied. Whenever inflammation has definitely passed on to suppuration, the abscess cavity should be opened by a free incision at the earliest possible moment. In deciding upon this the surgeon should exercise his judgment, and not necessarily wait until he can definitely obtain fluctuation, still less wait for pointing. This last was excusable before the introduction of anæsthetics, when an abscess had to be opened by puncturing and cutting out. Now it is wise not to wait for fluctuation, owing to the destruction of tissue which must ensue, whenever a diagnosis can be arrived at beforehand. A small incision into an abscess in which softening

at the centre is only just beginning is followed by rapid healing. In some cases the diagnosis may be confirmed by inserting a grooved needle or exploring syringe, pus escaping by the groove or being drawn up into the barrel. Even where nothing visibly escapes, a microscopical or bacteriological examination of the withdrawn needle may yield a positive result. But no conclusion can be drawn from a negative puncture. Such exploration with a needle must always be followed at once by an incision should pus be withdrawn, or in withdrawing the needle tissues superficial to the abscess may become infected. Thus in the case of an empyema thoracis suppuration may be set up in the chest wall. Hence also aspiration should never be employed when the needle has to cross a serous cavity to reach the abscess, as, for instance, the peritoneum to reach an appendix abscess, lest the abscess leak into the cavity through the puncture.

Incision of an abscess.—In order to open an abscess the patient should be anæsthetised with nitrous-oxide gas, followed by ether when the pus is deep-seated. An incision under local anæsthesia (freezing, cocain or eucain injection), or without anæsthesia, by puncturing and cutting out, is an indifferent method not only because of the pain, but because when dealing with an abscess in this way there is a tendency to wait for pointing, to make too small an opening, to omit the exploration of the cavity to learn its extent, and to abstain from freely treating the abscess wall with an antiseptic,—by all of which the formation of a sinus is favoured.

The patient being anæsthetised, a free incision is made generally in such a direction as will open a dependent part of the abscess and so favour drainage. A natural fold of the skin is selected if possible to prevent a visible scar. The course of large blood-vessels and nerves must be avoided. The skin and superficial structures are divided until the abscess is reached, or after incising the skin, a blunt instrument, dressing or clamp forceps, a grooved director, etc., is pushed in the direction of the tense swelling, and as soon as pus is found, the track so made is stretched (Hilton's method).

The pus is allowed to escape, then the cavity is wiped or gently scraped out so as to clear away pus and sloughs ; next it is swabbed out with a strong antiseptic (carbolic acid 1 in 20, perchloride of mercury 1 in 1,000), all of which is afterwards swilled away with water. Then the dried-out cavity is filled with iodoform gauze and a dry dressing applied, or if there is still much surrounding inflammation, a boric-acid fomentation.

When the abscess is multilocular, septa are carefully broken down with the finger and all recesses and pouches exposed and cleared out.

Drainage by the use of tubes is referred to under *Wounds*. But the method above described is very much superior to that formerly used of making a small incision and inserting a drainage-tube.

Counter-opening.—When an abscess is very large and the first incision is found insufficient and not dependent, especially when suppuration is becoming diffused, a second or counter-opening is made by thrusting sinus forceps from the bottom of the cavity towards the skin and cutting down upon the point. The forceps can then be used to draw in a drainage-tube, and the large cavity be well irrigated with hot water.

If hæmorrhage of a severe character follows it is generally venous, and is arrested by firm plugging; if arterial, the wound must be enlarged and the artery tied above and below the point of communication. If a cavity is opened, such as the peritoneum, it must be protected before the wall of the abscess is incised.

Chronic abscess.—A chronic abscess forms slowly and the signs of inflammation may pass unnoted. Pyogenic organisms, although the cause and present at first, often die after starting the abscess, so that the pus is found to be sterile, at least to simple bacteriological examination. Such organisms may have entered with a foreign body, have reached the spot through the skin or by way of the circulation, or have remained dormant after an acute inflammation. The character of the pus varies much with its origin; when tuberculous it will be thick, creamy or granular and white, or thin with curdy masses, with very few pus cells entire; when metastatic, the fluid may be thin, oily. The wall is usually thick, the outer layers fibrous, the inner surface smooth, velvety, like mucous membrane. Chronic abscesses are commonly tuberculous in origin; metastatic abscesses are chiefly due to pyogenic organisms.

A chronic abscess extends by burrowing, especially in a direction favoured by gravitation, as in spinal abscesses; it bursts upon a skin or mucous surface, and may then lead to hectic and amyloid disease, ending in death from exhaustion, or it may rupture into the brain or spinal cord and set up apoplectic symptoms.

A chronic abscess may remain latent for years, much of its fluid being absorbed, and the solid portion inspissated, forming a cheesy or calcareous mass. Then from a slight cause, a strain, blow, or impairment of health, inflammation is relighted, and a so-called *residual abscess* is produced. A tuberculous scar may remain quiet, yet on microscopic examination little cheesy or calcified areas may be found. In an abscess latent in the centre of a bone for many years, staphylococci have been discovered, in one twenty-five years after an acute septic inflammation.

Treatment of a chronic abscess.—Whenever possible a chronic abscess should be removed, wall and all, by dissection. If not, as much as possible of the wall must be scraped away and any foreign body, sequestrum, etc., removed, and thus the formation of a sinus will be avoided. Sometimes after excision the wound can be sewn up; or, after scraping, the cavity is plugged with iodoform gauze and redressed daily until it fills up. Large chronic abscesses, such as

those connected with the spine, require special treatment (see *Spine, psoas abscess*).

Sinus and fistula.—Although often used synonymously with fistula, a sinus means a track blind at one end and opening on the surface of the skin or mucous membrane at the other. A fistula has both ends open, giving rise to a communication between the skin and a mucous or serous cavity or joining two mucous cavities.

They are generally the result of suppuration, sometimes of an injury, but may be of congenital origin, and then due to the failure to close completely on the part of some embryonic fissure, such as the branchial fissures.

A *sinus* is often caused by carious and necrosed bone, a bullet or other foreign body, such as a drainage-tube which has slipped into an abscess and prevented healing. Another fruitful cause is the bursting of an abscess through a small hole in the skin. A sinus forms a narrow, often tortuous, channel lined by smooth or tuberculous granulations, surrounded by a thick fibrous wall and opening upon the surface in the midst of a prominence composed of granulations. From it by pressure pus can be expressed.

A *fistula* has a more varied aspect. It may resemble a sinus, but opens on a mucous surface at its deeper end, as in the case of a fistula in ano. A recto-vesical or vesico-vaginal fistula is a direct communication between the bladder and rectum or vagina, the mucous membrane being directly continuous. A salivary fistula results from an injury to Stenson's duct after which the saliva is discharged on to the skin instead of into the mouth. Some fistulæ are intentionally made to relieve the patient, *e.g.*, a colotomy.

Treatment.—A sinus should if possible be dissected out and the wound closed or filled with gauze. Failing this the next best way is to slit it up as completely as possible, well scrape the wall, treat it freely with an antiseptic, and then dress firmly with gauze to make it heal from the bottom. Less satisfactory measures are: to keep the external opening patent by a drain-tube, or by a loop of soft lead wire, or by inserting the head of a bone stud perforated through the stem. Into a sinus may be syringed chloride of zinc (1 per cent.), nitrate of silver (10 per cent.), or peroxide of hydrogen which breaks up the pus and escapes as froth. A probe dipped in pure carbolic acid may frequently be passed down, or the sinus may be cauterised under an anæsthetic by a narrow benzine cautery or galvano-cautery point. If the blind end of the sinus reaches towards the skin at some other point, and it is impracticable to lay it open, then a counter-opening may be made by cutting on the end of a probe and a drainage-tube passed right through; later the tube is divided and a short piece kept in each end. But drainage-tubes are not now so much in favour, as the tracks in which they lie are very slow in healing.

The treatment of the various forms of fistulæ is elsewhere described.

(B) **Diffuse suppuration.**—This occurs in the subcutaneous and intermuscular connective tissue, also in organs. It may be primary, and is then most often seen as cellulitis, due to streptococcus pyogenes (see *Erysipelas*), but may arise by the rapid extension of a previously circumscribed abscess. In an organ a number of separate foci may rapidly fuse together, as seen in the breast, kidney, etc.

When well established, a condition very dangerous to life arises, since incisions and drainage are likely to be inefficient. Hence removal by amputation of a limb or excision of an organ such as the breast or kidney may be required.

(1.) **Suppuration on a surface, mucous or serous.**—(*a*) *Muco-purulent inflammation* (Fig. 9) is an intensification of the inflammation of a mucous membrane. The flow from the surface, which in simple inflammation is largely serous, becomes thicker and more ropy from the admixture of mucus, and more opaque from the increasing number of cells until the appearance is that of pus. As the discharge continues, it may get a green tinge from the bacillus pyocyaneus. Microscopically, a marked exudation and multiplication of leucocytes is seen, which collect first in a dense layer in the sub-mucous tissue, and then passing up between the epithelial cells reach the surface. At the same time an active secretion of mucus is going on from the numerous goblet cells, and also from the racemose glands. If the inflammation continues the epithelial cells degenerate and their place is taken by small round cells; thus the whole layer of epithelium may be destroyed and ulceration extend into the submucous tissue. As the inflammation subsides and the emigration of leucocytes slackens, active proliferation of cells appears in the submucous connective-tissue tending to repair, and the gap in the mucous membrane is covered in from each side by the epithelium spreading over, the cells showing active mitosis.

Fig. 9. — Muco-purulent inflammation. 1. Muco-pus on surface. 2. Goblet cells producing mucus in excess, and leucocytes passing towards the surface to become pus cells. 3. Leucocytes in the submucous tissue. 4. Leucocytes emigrating from dilated vessels. 5. Alveoli of mucous glands actively secreting.

Symptoms.—The local signs of muco-purulent inflammation are only seen when near an orifice; the constitutional signs of fever

exist sharply at first, then decline. The patient suffers chiefly f the loss of function of the involved track, or the retention of muco-pus. The muco-pus may be retained in a mucous cavity, s as the maxillary antrum, the frontal sinuses or the middle forming an *empyema*, and be followed by complications from ext sion to the bone. Or it may spread along a mucous tract, as gonorrhœa, from the urethra backwards. The organisms n penetrate the mucous membrane and pass into the circulati especially when the inflammation involves the throat or intestines.

Causation.—It is generally due to infection by micro-organisn but occasionally may result from injury, heat or caustics. T organisms connected with muco-purulent catarrh are still obscu *e.g.*, in the case of a "common cold" or "influenza." The strep coccus pyogenes is the cause of a dangerous œdematous inflammation the throat, the gonococcus is especially well known; the staphyl coccus and pneumococcus may both cause muco-purulent inflamm tion. Naso-pharyngeal muco-purulent inflammation follows on t specific fevers, measles, scarlet fever, either directly or indirect through debility, etc. The various forms will be described und their special headings.

The *treatment* involves the improvement of the general healt the getting rid of the muco-purulent secretion, especially if retaine in a cavity before complications arise, and the topical application astringents, etc.

(*b*) *Sero-purulent inflammation.*—Inflammation on a serous surface as already mentioned, involves an excessive formation of lymp containing a variable degree of fibrinogen, partly secreted, partly transuded. The more severe the inflammation, the greater the escap of leucocytes, which, breaking down, liberate a ferment changing the fibrinogen into fibrin. This fibrin adheres in part to the serous surface forming layers, whilst in the sub-serous connective tissue rapid emigration of leucocytes takes place, which pass to the surface, and largely destroy the serous lining and invade the fibrinous layers. With the onset of suppuration these leucocytes become pus corpuscles, a turbid fluid taking the place of the serous exudation. The character of the pus will vary according to the amount of fibrin and serous fluid. The *cause* is in all cases micro-organisms. These may reach the cavity from the outside, pyogenic organisms entering a joint or the peritoneal or pleural cavity, through a wound. The same organisms, or the gonococcus or the colon bacillus, may reach the peritoneum from the intestine or genito-urinary tract. Empyema thoracis is apparently set up by many organisms, especially by the pneumococcus. The tubercle bacillus is a great determinant of suppuration in joints. The *signs* of sero-purulent inflammation are partly local, due to distension of a cavity with fluid; and partly general, due to absorption from a large area. However, pus may be retained in a cavity,

especially when it follows a serous inflammation, without showing any marked constitutional influence, presumably because the lymphatics from the serous surface become blocked during the stage of serous inflammation. The *treatment* consists in early evacuation and drainage; by this means complications caused by extension are avoided.

(2.) **Superficial suppuration, pustulation, and ulceration.** —In the tissues beneath the surface, the emigrating leucocytes and proliferating-tissue cells which degenerate collect in the fluid exudation at the focus of the inflammation to form an abscess. When the abscess is near the surface the skin degenerates and the pus escapes as a discharge, leaving an area corresponding to the wall of an abscess, an ulcer. An abscess may therefore be said to be a closed ulcer, an ulcer an open abscess. Ulceration is distinguished from sloughing and gangrene in being a molecular death, as compared to the death of visible pieces or in masses. But there is no sharp line of division. The ulceration occurring in a true tumour or new growth is a combination of a degeneration of the new growth connected with an impaired blood-supply, together with an inflammatory infection of the tumour by organisms from a skin or mucous surface.

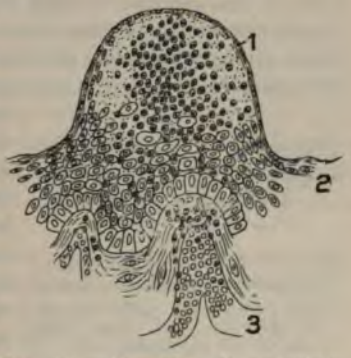

FIG. 10. — Formation of a pustule. 1. Pus cells and exudation collecting and raising the corneous layers of the epidermis. 2. Epidermis with leucocytes passing upwards between the cells. 3. Dilated vessels in the subepithelial tissue from which the leucocytes are escaping.

We will take first the naked-eye appearances attending superficial suppuration and the formation of an ulcer. An area of skin becomes inflamed, with deeper redness, more swelling and tenderness at the centre. There the tissues feel indurated, a more or less distinct swelling occupying the skin and subcutaneous tissue, which pits from œdema. At a spot in the centre the corneous layer of the epidermis appears whitish, and is raised by a fluid collection beneath into a pustule (Fig. 10). The contents, according to the stage, may be serous, slightly turbid from a few leucocytes, or whitish pus when there are many cells. The corneous layers of epidermis becoming detached, an excoriation is formed, exposing the deeper layers of the epidermis and dermis, punctated by the dilated capillary loops in the papillæ. Supposing the process to be arrested, serous exudation containing a few degenerating leucocytes escapes, while the deeper layers of the epidermis quickly proliferate and cover in the raw surface.

If, however, on the epidermis being detached the dermis appears greyish, blood-stained, or greenish, and does not show any bright vascular points, the whole thickness of the skin is in process of destruction, and an ulcer forms. The ulcer is at first covered with thick whitish or greyish, or blood-stained, sanious pus, through which there appear brighter points or granulations, until the whole surface of the sore is covered in this way. Then epidermis begins to spread from the periphery over the surface as a shelving bluish margin, whilst the discharge gets less, until the raw surface is skinned over and a scar is left to mark the previous situation of the ulcer.

The *minute changes in ulceration* are as follows (Fig. 11):—The blood-vessels in the subcutaneous tissue are first dilated, then at the focus of inflammation there is stasis, thrombi forming in the capillary loops of the papillæ. Along with this there is a rapid emigration of polynuclear leucocytes into the surrounding connective tissue, which multiply by direct division. At the same time the pathological exudation infiltrates the subcutaneous tissue, and soaks upwards amongst the epithelial cells, blurring their outline and tending to collect and raise the corneous from the deeper layers of the epidermis. The leucocytes pass upwards, at first by intercellular channels as long as the epidermal cells are intact, and collect in the cavity with the fluid exudation, so as to raise the epidermis and form a pustule. Then the cells of the epidermis and dermis and connective-tissue fibrillæ swell, become turbid, and break down into granular débris, and are added to the pus. Next there starts in the deeper zone of inflammation the process of regeneration (Fig. 11); proliferation of endothelial cells of the capillaries and lymph-spaces and of connective-tissue cells takes place by karyokinesis, and a zone of potential fibroblasts tends to form and arrest the extension of the ulceration. New capillary loops sprout upwards from the pre-existing vessels, and around each the fibroblasts arrange themselves, each loop and its surrounding group of cells forming a naked-eye granulation. Whilst some of these fibroblasts on the surface degenerate and fall off as pus cells, poisoned by the toxins, the deeper ones are rapidly forming young fibrous tissue, which contracts into scar tissue, thus diminishing the extent of the surface to be covered in. With the vascularisation of the base of the ulcer, the Malpighian layer of epidermis begins also to rapidly divide by mitosis, and so to spread new epidermis over the healthy granulations.

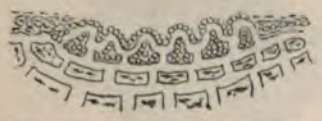

FIG. 11.—Diagram of ulceration. Formation of granulation tissue. New capillaries growing out amongst the small round cells from the old capillaries.

Scar or cicatrix.—The fibrous tissue continues to shrink, leading to obliteration of the blood-vessels in the cicatrix and causing contraction and often distortion of the surrounding parts. Cicatrices differ from

normal skin in that they are devoid of sweat-ducts, hair-follicles, sebaceous glands, papillæ, and lymphatics, and being also but poorly supplied with nerves and having a badly-regulated blood-supply are very apt to break down on slight provocation, leading to a re-opening of the ulcer. Moreover, owing to their unstable nature, they are liable to undergo certain changes and become the seat of eczema, hypertrophy, keloid, epithelioma, and warty excrescences, and to be attended with itching, pain, and intense neuralgia.

Instead of thus healing, *the ulcer may extend*, the deeper inflammatory zone becomes that of stasis, the connective tissue and cells further degenerate, any cells which have proliferated die, whilst the emigration and fluid exudation from the blood-vessels continue.

When an ulcer neither heals nor extends the deepest inflammatory zone becomes occupied by dense scar tissue, which in contracting diminishes the blood-supply to the surface, and checks its return by lymphatics and veins. Thus the granulations on the surface are pale, œdematous, congested, showing lack of arterial supply with obstructed venous and lymphatic return, whilst the production of fibroblasts is equalled by their destruction. Meanwhile the epidermis at the margin cannot spread over the surface, but all freshly-formed cells fall off into the pus.

Causation.—Superficial suppuration, pustulation, and ulceration are practically always caused by micro-organisms. Chemical substances, especially perchloride of mercury and croton-oil, being rubbed on the surface of the skin set up pustules; how far this may result from direct injury by these substances, or how far they diminish resistance to the attack of organisms already present in the epidermis, hair-follicles, and ducts of the sebaceous and sweat-glands, is doubtful. Organisms, especially staphylococci existing as latent saprophytes in the above situations, may, as the result of anything lowering the vitality of the skin, become pathogenetic. This tendency is directly combated in cleaning and preparing the skin of a patient for operation. Pure cultures of staphylococci rubbed into the uninjured skin easily set up pustules, furuncles, carbuncles. The combination of slightly impaired health with local rubbing, as a cause of superficial suppuration, is frequently illustrated in practice, wherever hair-follicles and sebaceous glands are numerous, as in the armpit. Small scratches and punctures of the skin allow staphylococci, also streptococci, to enter; the resulting suppuration is partly due to the activity of the inoculated germ, and partly to the lack of resistance of the patient; the former is shown when the organisms have been derived from a source of virulent infection, *e.g.*, a post-mortem wound; the latter, when a slight scratch becomes important in a weakly patient. Superficial suppuration and ulceration may be metastatic in origin, as seen in the course of smallpox or syphilis, in which the relationship

to particular organisms is still in doubt; in others, the organisms causing metastases are clearly staphylococci.

Predisposing causes, so called, are all connected with impairment of nutrition, local or general, and diminished resistance to organisms. 1. Poor living, advancing age, overwork, bad hygiene. 2. Definite morbid states; such as syphilis and tubercle. 3. Local disturbance of the circulation, as from diminished arterial supply, especially illustrated in the case of bed-sores, venous congestion as caused by long standing, varicose veins, or lymphatic obstruction, as seen in ulcers of the leg.

Treatment.—The general line of treatment of superficial suppuration and ulceration may be considered under the following heads:

1. Preventative.—Cleanliness and the maintenance of the skin in health. Particular attention is now paid to this matter—

(*a*) In preparing and cleaning the skin of a patient before operation, or in dressing a wound, so as to remove all organisms present both on the epidermis, in concretions of sweat and dirt and hair, and in the mouths of sebaceous and sweat-glands and hair-follicles (see *Wounds*).

(*b*) In nursing patients, lest the slightest collection of sweat and dirt, rubbing, or pressure may in a feeble patient cause a bedsore (see *Bedsores*).

(*c*) In the observance of habitual cleanliness, where this is apt to be neglected as regards the hairy scalp, beard, nape of the neck, armpit, groin, genital and anal folds of skin, and on the legs, the treatment of eczema, before it becomes well established.

2. The early removal of the epidermis of a pustule, allowing the escape of the contents and the opportunity for the excoriated surface to become re-covered by epidermis, so leaving no mark or scar, especially illustrated in the early treatment of smallpox pustules. A small incision is made into a pustule, the pus washed out, and whilst the epidermis is lifted by a probe, some iodoform is dusted in.

3. The whole thickness of the skin being threatened or already destroyed, the pus and degenerating tissues should be scraped away, and the organisms killed by antiseptics; the ulceration is thus prevented from extending, and the proliferation of connective-tissue and endothelial cells promoted. Capillary loops rapidly spring up, and are followed by the covering of the vascular surface with epidermis. The greater the tendency to spread, the more the need for active antiseptic treatment and scraping. By early treatment the tendency to a chronic ulceration is prevented; see, *e.g.*, *Boils and Carbuncles*.

4. A chronic ulcer existing, the object of treatment is to obtain a vascular surface, by scraping down to and through the fibrous layers until a vascular zone is reached, when by suitable dressing a surface covered by vascular granulation is obtained.

5. If the raw surface is great, the epidermis cannot spread over rapidly, so that a chronic ulcer is in danger of developing, or if it ultimately can do so, marked contraction and scarring, liable to complications, result. In such cases skin-grafting is indicated as soon as there is a healthy vascularised surface (see p. 39).

Ulcers.

An ulcer is the term applied to an open sore produced by a loss of substance of the free surface of the skin or mucous membrane in the process of ulceration, or of ulceration and gangrene combined. The term, moreover, is sometimes extended to any open granulating wound the result of an injury or operation.

Varieties of ulcers.—The various names given to ulcers are derived either from their local conditions and surroundings or from their specific cause. The characters of the specific ulcers, however, often become obscured by accidental local conditions, and these latter again are constantly changing from day to day, so that an ulcer which at one time would be called callous may at another be in a sloughing state. The following are examples of the chief types of ulcers, but in practice many minor shades of difference in the local appearances are met with, so that it may be difficult or impossible to assign a given ulcer to a particular type.

The simple, healthy, or healing ulcer.—The edges are smooth and shelving, and extend in the form of a bluish-white film over the marginal granulations. The base is level or nearly so, and covered with healthy granulations. The discharge is inodorous pus, or if the ulcer is dressed antiseptically, and all irritation avoided, serum with a few pus corpuscles. The surrounding skin is healthy. This is the type that all ulcers assume when healing. *Treatment.*—Rest and protection by porous, unirritating antiseptic dressing. When large, cicatrisation may be promoted by skin-grafting.

The exuberant or fungous ulcer is generally due to obstructed venous return from the granulations, the result of undue contraction of surrounding tissues, as seen, for example, after a burn. The edges are healthy, but the granulations rise up above the surface, and are turgid, dark red, redundant, and readily bleed. The discharge is purulent. *Treatment.*—Solid nitrate of silver or sulphate of copper should be rubbed over the granulations until they are reduced to healthy proportions.

The œdematous or weak ulcer generally occurs in connection with tuberculous bones or joints, but any ulcer may become œdematous if healing is delayed by the too long use of emollient applications The edges and surroundings are generally healthy; and the granulations are upraised, flabby, bulbous, semi-translucent, gelatinous, and friable. The discharge is profuse and watery. *Treatment.*—

Removal of the cause where possible; uniform pressure; and applications of lotions of nitrate of silver or chloride of zinc, or like astringents. When the ulcer is tuberculous the granulations should be scraped away.

The inflammatory and inflamed ulcer.—These terms are applied to ulcers in which the inflammatory phenomena are the most marked feature. The inflammation may depend on some constitutional disturbance consequent upon alcoholism, poor living, and the like; or it may be the result of local irritation applied to any ulcer, whatever its previous character. For the purpose of distinction, the term "inflammatory" is applied to the former condition, whilst the term "inflamed" is generally restricted to ulcers of the latter class. Inflammatory ulcers have generally an irregular shape, the edges are ragged and shreddy, or abrupt or sharp-cut; the surrounding skin is red and œdematous, and the base void of granulations, dry, livid red, or covered with a serous or sanious discharge mixed with tissue débris, and if the inflammation is very acute, with yellow sloughs. When inflammation attacks a previously granulating ulcer, the granulations become florid and swollen, and generally slough, whilst the surrounding parts present the ordinary inflammatory phenomena. The *treatment* should consist of rest, the elevation of the part, the removal of all local irritation and septic contamination, the application of warm fomentations of boric acid, attention to the constitutional state, and regulation of the bowels.

The sloughing ulcer.—This is merely a severer degree of the former, and it differs from it in that the inflammatory process is more intense and of a spreading character. It is often met with in connection with venereal disease, especially when mercury has been given to excess. The micro-organisms at work in this and the next form of ulcer are probably only the ordinary pyogenic micrococci found in all ulcers, but here acting with greater intensity in a vitiated constitution. The ulcer spreads with great rapidity, the edges are undermined, inverted, and dusky red, and the base is covered by an ash-grey or black slough. There is commonly much pain and severe constitutional fever. The *treatment* is similar to that of the inflamed variety. Antiseptics should be freely used if the ulcer is foul, and opium given if there is much pain. When due to syphilis, mercury and iodides should be used cautiously, and be altogether withheld on the first sign of mercurialism.

The phagedenic ulcer.—Owing to the antiseptic treatment of wounds and the better sanitary care of patients collected together in hospitals, the phagedenic ulcer is rarely seen, even in war time (see *Hospital Gangrene*). It now generally arises in connection with venereal sores, probably by direct inoculation, and in chronic ulcers of the leg from neglect. Its special characteristics are due probably to a mixed infection of pyogenic organisms, and of a special gas-forming bacillus (see p. 111). The edges of the ulcer are irregular, swollen,

and undermined, and the skin around is of a dark purplish, or dusky red colour. The surface shows no granulations, but is covered with foul, greenish, pulpy sloughs, beneath which the connective tissue is greyish, infiltrated with pus, and discharging a dark, blood-stained ichorous fluid. When there is a rapid extension, both superficially and towards the depth, it is spoken of as *Sloughing phagedena.* The sloughing may occur with fearful rapidity, destroying the penis, vulva, and penetrating to the rectum or bladder, or extend rapidly round the leg and down to the bone with severe fever of the asthenic or typhoid type. *Treatment.*—The patient must be at once placed under an anæsthetic, and all the sloughs cut and scraped away until vascular tissue is reached. Then caustics, the cautery, or strong antiseptics are applied. One of us (Walsham) prefers fuming nitric acid as being most efficacious and radical; the remaining acid can be neutralised by carbonate of soda. Others employ pastes of arsenic, chloride of zinc, or caustic potash; others, again, prefer the cautery, as its use can be more exactly regulated. The pain which follows must be relieved by opium. Pure carbolic acid, or perchloride of mercury (1 in 500 of spirit), well rubbed in, then all swilled away with water, acts most efficaciously. The use of pure carbolic acid is now very general, for it is followed by so very little pain that no opium is needed, and is thus applicable when the kidneys are not sound. The dressings may consist of iodoform powder and gauze, of sterilised gauze wrung out of 1 per cent. permanganate of potash; or continuous irrigation, or baths containing the permanganate may be adopted. Internally, a nourishing diet and stimulants are indicated. Mercury, also iodide of potassium, must be stopped or only a very little given. Good ventilation is required, and to reduce the odour, a steam spray of eucalyptus, etc., may be kept going.

The chronic, callous, or indolent ulcer.—This condition of an ulcer is the result of continued irritation and neglect, in consequence of which the edges become infiltrated with inflammatory material, which impedes the circulation and prevents healing. It is very common in the lower third of the leg in the poorer classes. The edges are smooth, white, callous, rounded, steep, and quite insensitive when touched. The skin around is generally congested or eczematous. The base is covered with a thin sanious discharge, whilst there are either no granulations, or such as are present are small, flabby, pale, and ill-formed. These ulcers often exist for years, and are usually attended with but little pain, and though they are at times small, at other times they extend nearly round the leg. They are often adherent to the fascia, periosteum, or bone. Old callous ulcers, when subjected to continued irritation, are apt, as age advances, to become epitheliomatous. *Treatment.*—The callous edges should at first be softened by emollient dressings, and uniform pressure subsequently applied by a Martin's bandage, by strapping and a bandage, or by Unna's dressing. The strapping

plaster, cut into strips one inch and a half wide, should be evenly applied, and extend two inches below and a like distance above the ulcer. Holes should be cut in the strapping opposite the ulcer to allow of the escape of the discharge. Over the strapping a bandage should be applied from the foot to the knee. The bandage should be changed daily; the strapping once or twice a week. Iodoform or some other antiseptic powder should be sprinkled on the ulcer beneath the strapping. Unna's paste (oxide of zinc 10 parts, gelatine 15 parts, glycerine 30 parts, and water 45 parts) may be applied as follows:—The limb is bandaged with carbolic gauze from toes to knee, covering in the ulcer. A layer of the melted paste is next applied, allowed to dry, and the process repeated. The contraction of the paste exercises uniform pressure on the ulcer, also on the limb above and below. When the ulcer is very large it may be scraped down to vascular tissue, and treated by skin-grafting; when it extends quite round the leg or shows signs of becoming epitheliomatous amputation is called for.

The varicose, hæmorrhagic, and eczematous ulcer.—These terms are applied to any ulcer, whatever its other characters, when associated respectively with a varicose state of the veins or an eczematous condition of the skin. Both conditions frequently occur together, and are described under *Varicose Veins*. If there is a bleeding point, it should be made the centre of a crucial incision.

The irritable or painful ulcer.—Though any ulcer may be irritable or painful, the above terms are generally restricted to a small painful ulcer of the anus (see *Diseases of Rectum*), and to a small, superficial, generally congested ulcer, commonly situated about the ankle, and occurring chiefly in women beyond middle life. The pain is often intense, and is generally believed to depend upon the involvement of the nerve-endings. *Treatment.*—The improvement of the general health, small doses of opium, and cauterisation with nitrate of silver will often suffice to cure the ulcer. In inveterate cases an attempt may be made to divide the nerve-twigs subcutaneously, after the manner of Hilton, by passing a tenotome beneath, or the ulcer may be dissected out.

Tuberculous ulcers are generally due to the breaking down of enlarged tuberculous lymphatic glands, the bursting of subcutaneous tuberculous abscesses, or the ulceration of tuberculous or so-called strumous nodules. They are generally multiple and often confluent, forming an irregular indolent sore. The edges are pale, bluish-pink, thin, and undermined. The granulations are pale, œdematous, protruding, and readily bleed when touched. The discharge is thin, yellowish-green and scanty. Enlarged glands and cicatrices of former ulcers are frequently present in the near neighbourhood. The cicatrices are generally raised, pale pink or white, whilst the skin is often puckered-in around them. *Treatment.*—Constitutionally that for tubercle. Locally the sore should be destroyed by paring

away the edges and scraping the base with a Volkmann's spoon. The cicatrices may sometimes be with advantage excised, so as to replace them by a linear scar. If there is a tendency to keloid, this should not be done, but belladonna or mercury ointment applied. If the scar is depressed, a tenotome may be passed subcutaneously beneath it.

Syphilitic ulcers.—Primary ulcers or chancres are described under *Syphilis*. Those occurring in the course of constitutional syphilis may be divided into the superficial and deep. (*a*) The *superficial* occur in the course of pustular and tubercular syphilides, and are often associated with patches of these eruptions on other parts of the body. They are usually circular or crescentic in shape, spreading by their convex margin, and healing by their concave. Their edges are sharp-cut and often surrounded by an areola of dusky redness; their base is but slightly depressed, and of a dark red colour, and is often covered by a yellow slough or a rupial or ecthymatous scab. Several of these ulcers frequently coalesce, giving rise to a serpiginous or annular form of ulceration, which is very characteristic of syphilis. (*b*) The *deep* are due to the breaking down of gummata. They are circular or oval in shape; their edges are steep, sharp-cut, slightly scooped out, and of a dull red colour; and their base is depressed and covered with a yellow wet-wash-leather-like slough and the débris of breaking-down tissue. They leave slightly depressed, white cicatrices, often surrounded with pigmentation. *Treatment.*—Constitutionally, iodide of potassium should be given in full doses, combined in obstinate cases with small doses of mercury; whilst locally a boric-acid fomentation may be applied till the slough has separated, and then black-wash, iodoform, or the red oxide of mercury ointment.

Gouty ulcers are such as are met with over gouty parts. They are small and superficial, and the discharge as it dries leaves a chalk-like deposit of urate of soda on the surface of the ulcer. The *treatment* is that for gout. Locally they should not be scraped or irritated, but an ointment of lead and opium applied.

The scorbutic ulcer.—Should an ulcer exist in a person affected with scurvy the granulations become prominent, and of a dusky purple colour, and its surface becomes covered by a spongy, dark-coloured, strongly-adherent fœtid crust, the removal of which is attended with free bleeding, and is followed by the rapid reproduction of the same material. The *treatment* is that for scurvy.

Malignant, rodent, carcinomatous, and sarcomatous ulcers will be found described in the sections on Lupus, Tumours, etc.

Bedsores.—Decubitus.—An ulceration is very liable to take place in weakly bedridden patients owing to pressure and the irritation of sweat and dirt. The more helpless the patient the more liable he is to bedsores, and especially when he is paralysed, delirious or insane. They occur on the sacrum and buttocks whilst

lying on the back, over the great trochanter when lying on the side, higher up on the back when the spine is curved, or there is a hollow or ridge in the bed. They form on the anterior iliac spine, the bent knee, and the dorsum of the foot from weight of the bed-clothes; and on the olecranon in bronchitic patients who rest on their elbows to fix the humeri so as to allow the pectorals to expand the thorax. The occiput may become the seat of an ulcer in a rickety, neglected child whose head sweats, from resting on a hard mattress. Sores are easily set up by the pressure of splints on the point of the heel, over the malleoli, sides of the knee or elbow, or where the end of a splint cuts into the patient's buttock, fork or armpit.

Bedsores are *prevented* by efficient nursing, but it is the duty of the medical man to supervise, to see that the nurse is properly supplied with necessaries, is not overworked, and has assistance in turning heavy patients; also splints must be constantly attended to, and the surgical measures modified to suit the circumstances. Although sometimes most difficult to prevent, yet no bedsore can be looked upon as inevitable. Hospitals for paralysis, infirmaries and asylums, by improvements in nursing have rendered it quite exceptional for a serious bedsore to arise there.

The bed must be made with a firm, smooth mattress; the under sheet and blanket must be changed before they are saturated with sweat. The draw-sheet is spread without creases, foreign bodies such as bread-crumbs, etc., are swept away. The chief preventative measure is the frequent washing of all spots, subjected to pressure and friction, with hot water, soap and flannel or sponge, swilling clean, and completely drying with a smooth, warmed towel. Most weakly patients require this once or twice a day, and some much oftener, every three hours or so. Excess of dirt or sweat is dissolved first of all by turpentine or ether. Lotions of lead, zinc, silver or spirit must be viewed as supplements to the hot soap and water, not as substitutes.

Urine, fæces, and wound-discharges must be prevented from soiling the patient and his bed. Urine can be received into a flask-shaped bottle in the case of a man, or into a large test tube in the case of a small boy; incontinence is checked by frequent irrigation and catheterism, or by tying in a catheter. Urine continually escaping from the perineum or from a woman should be received into a pad of wool or moss, which is changed before saturation. Fæces are collected in a bed-pan or on a pad, the bowels being regulated by aperients and enemata.

Patients require to be frequently turned, young people can be kept prone. Pillows, air-cushions, water-beds, and in children immersion in a bath, are means of relieving pressure.

Signs of threatened bedsores.—The skin loses its proper colour; it remains a dead white, or it is dusky red, and the redness does not disappear on pressure; the skin feels indurated, œdematous. The

epidermis becomes raised as in a blister, or there are several points where pustules are forming. The epidermis becomes detached, forming an excoriation, exposing the papillæ. With proper care an actual ulceration can still be prevented. Failing this, the skin sloughs and an ulcer forms, which may be classified under one of the foregoing heads. A sloughing, gangrenous ulcer may rapidly extend, expose bone, and spread to the spinal cord, when the patient dies of septic spinal meningitis.

When simply an excoriation, active preventative measures are taken and some boric-acid ointment is applied and frequently changed. When an ulcer has formed, the gangrenous skin is raised and iodoform gauze slipped underneath. Sloughing is arrested by scraping and the application of pure carbolic acid under an anæsthetic. When healthy granulations have covered the area, epidermal grafts may be applied.

Skin-grafting.—(*a*) *Grafting of epidermis.*—*Thiersch's method.*—The ulcer having been brought into a healthy condition, excessive granulations are scraped off, all traces of antiseptics are washed away with boiled salt solution, and the surface pressed with a hot sponge until oozing has stopped. The skin of the patient's arm or thigh has been previously prepared, all antiseptics being likewise washed away. Then, under anæsthesia, the skin is made tense both longitudinally and transversely, and with a broad sharp razor, well wetted with salt solution, a shaving of epidermis is cut by drawing movements so that the section folds upon the upper surface of the knife. The section should be just through the tips of the papillæ, as seen by their bleeding points, and should not go deep enough to enter the subcutaneous tissue. The section is then carried to the ulcer on the razor, one end of the strip held down to the skin by a probe whilst the razor is drawn back, so that the folded section now spreads over on the ulcer and is then smoothed out. Air-bubbles are got rid of by a pipette, and the whole gently pressed down upon the surface. Some float the grafts out in salt solution, and then take them up on a large section lifter. The grafts should be large enough to well overlap the margins, as they will retract a little. Strips of green protective and then an open-meshed bandage is applied, and changed in a day or two, the meshes of the innermost layer of bandages being syringed through. After four to six days, all the dressing is changed and a lanoline ointment applied. The corneous layers become detached from the grafts, the Malpighian layers remaining as a transparent film which gradually thickens. The result is a non-indurated, supple scar, not liable to eczema or contraction. Such grafts may opportunely be obtained from a limb which has to be amputated; they may be spread out between layers of damp sterilised gauze and so be kept viable for some days, even as long as three weeks. The one thing to avoid is the contact of the grafts with antiseptics such as carbolic acid or perchloride of mercury.

The surface from which the graft is shaved requires to be treated like a superficial burn.

The same method may be used with less certainty for grafting fresh raw surfaces after much skin has been lost, but the surface is not so uniform, and blood is apt to ooze out and raise the graft. Generally, it is better in such a case to apply iodoform gauze until the surface shows granulations, and then graft secondarily.

(*b*) *Grafting of skin.*—Owing to the success attending the use of epidermis, skin is not now so much used. The graft may be raised from some loose area, which can afterwards be sutured, or it may be taken from an amputated leg, or from the prepuce removed by circumcision. The chief thing to attend to is that no subcutaneous fat remains on the under surface of the graft. Frog skin, that from the plucked breast of a chicken, or the skin of a rabbit or dog is not much used.

(*c*) *Plastic operations.*—These will be alluded to in connection with the nose, breast, etc. When the skin is raised from the underlying subcutaneous tissue it becomes much more extensile and may thus be stretched over a larger area, or a flap may be twisted round still remaining attached at one part, which may be divided when the flap has become adherent. In this way the nose may be covered with a flap of skin from the forehead or from the arm.

GANGRENE.

Gangrene is a term specially applicable to an eating sore, such as phagedena, or hospital gangrene, and is now the general term for partial death of tissues, especially of the limbs. The changes which end in the death of tissue are spoken of as *sphacelation* or *mortification*. *Sloughing* is the process of separation and casting off of the dead tissue (the *sphacelus* or *slough*). The distinction of traumatic from other forms of gangrene is of no great importance ; only when the gangrene is a direct result of the injury, the circulation being arrested by a mechanical crushing, can it be termed such. In many of the so-called cases of traumatic gangrene the actual injury is but slight, the gangrene resulting from septic inoculation, or in other cases from pre-existing pathological changes. The terms *idiopathic* or *spontaneous*, as opposed to *traumatic gangrene*, are also unsuitable terms as the diseased conditions inducing gangrene are now better known. The division into *dry* and *moist gangrene* is largely accidental, according as the arterial or the venous circulation is chiefly obstructed, and the limb is maintained in dry or in moist surroundings.

Mortification or sphacelation.—General outline of the process of gangrene.—The dead part in *dry gangrene* exhibits the same changes as are seen after death in the body generally : the skin becomes absolutely cold, white, or marbled by stagnant blood in the surface veins ; rigor mortis may appear for a short while ; the limb is

bloodless when cut into. Then the bloodless limb in dry surroundings mummifies; the colour of the skin deepens to an olive, next to a blackish brown; it is horny and rings when struck; the muscles beneath are reddish and the whole has a musty odour. There is practically no absorption from this dead part except during the stages before the complete cessation of the circulation.

In *moist gangrene* the limb has been previously distended with venous blood; has been inflamed, hot, red, painful, a peculiar burning pain being felt just before the cessation of all circulation. Then the limb ceases to be painful and becomes cold, and putrefaction, such as occurs in a moist medium, sets in. The hæmoglobin of the red blood corpuscles diffuses and gives the limb a dusky red or brown colour, which changes gradually to green. A foul odour of decomposition is perceived, swarms of organisms appear; the cuticle is slimy and easily separates; the dermis beneath is greenish and is soon detached with the least touch; beneath are seen the muscles liquefying, the connective tissues blending into tough sloughs and exposing the bone. The products which can be absorbed, especially when the stage of dying is slow and continuous, as in spreading gangrene, are those of putrefaction, poisonous nitrogenous derivatives of albumin, resembling precursors of urea, like the toxins and plant alkaloids, also irritating fatty acids, and gases, hydrogen sulphide, and marsh gas.

The line of demarcation.—Sloughing.—The dead tissue separates by ulceration at the expense of the living. At first the line of demarcation is ill defined—in dry gangrene because there is only a feeble circulation in the living and the putrefaction in the dead part is slow; in moist gangrene, because the line round the limb is irregular and the gangrene is still spreading in places. In the dead part there is no sensation; in the living it is retained, or there is hyperæsthesia or pain. The dead part is cold and remains so; the living is warm and gets warmer near the gangrenous zone. On indenting the dead part with the finger the colour is not altered; the living skin becomes paler and recovers colour on withdrawing the finger. When the dying or dead part is swollen it pits on pressure and the pit remains; in the living the pitting disappears on taking off the finger-pressure. The line of demarcation is first shown by a zone of inflammatory redness at the edge of the living part, then a line of ulceration appears, with pus beneath whitish epidermis, and this on being removed exposes an irregular gutter which gradually deepens and encircles the limb.

In dry gangrene of a limb there forms a cone-shaped ulcerating surface covered by vascular granulations, discharging very little pus, the skin being destroyed highest up, then the fascia and muscles, and lowest of all the bone, which is finally eaten through, leaving a conical stump with the bone projecting. This process of separation may take as long as a year or two. Meanwhile the patient has much

the same amount of absorption, and is subject to the same intercurrent complications as from a chronic ulcer of the same extent. In moist gangrene there is profuse ulceration at the end of the living part, with much septic absorption; pus tends to track up between the muscles and necrosis to spread up the bone. Thus, if the limb is not removed by amputation, the patient dies from septic complications before the actual process of separation has gone very far. In spreading gangrene previously healthy tissue is being continuously invaded and fresh absorption takes place, rapidly poisoning the patient by toxins, or inducing septicæmia or pyæmia.

Causation of gangrene.—In whatever way it takes place the onset of gangrene is the result of the partial or complete *failure of the blood to flow through the affected part.* This may be due to (1) Impairment of the general circulation. (2) Arterial obstruction, obstruction of main arteries, small arteries or arterioles. (3) Venous obstruction, small veins or main venous trunks. These three factors are usually more or less combined.

1. *Causes which impair the general circulation* (the so-called *predisposing* causes of gangrene).—Old age, feeble heart's action from exhaustion, fatty degeneration, results of endocarditis, Bright's disease, diabetes, anæmia, especially acute anæmia from hæmorrhage.

2. *Physical or mechanical causes.—Traumatism.*—Crushing of the whole or part of a limb, burns and scalds, frost-bite, acids and alkalies, pressure as in bed sores, strangulated hernia, or by tumours, fractures and dislocations, foreign bodies, and in the fœtus constriction by amniotic bands, and from the use of tight bandages and elastic tourniquets.

3. *Inflammatory causes*—obstructing, especially capillaries and venules, due to organisms—the pyogenic organisms, staphylococci or streptococci, erysipelas, puerperal fever, the gas-forming organisms (see p. 111), bacillus anthracis, bacillus ærogenes capsulatus (Welch), bacillus coli communis, etc., seen in carbuncle, phagedena, noma, etc. Multiple patches of gangrene appear on the skin, especially in exhausted children.

4. *Obstruction to the main* artery and vein by ligature, rupture, pressure, embolism or thrombosis. Anatomical conditions may be unfavourable to a collateral circulation, as in the case of the axillary artery or vein, and the common femoral artery and vein (see *Ligature of Arteries*). The collateral circulation may be anatomically good, yet be impaired by external pressure, or by extravasated blood, by disease of small vessels, by inflammation, by feeble circulation, by multiple embolism or thrombosis. As there is no anastomosis between the branches either of the pulmonary or of the superior mesenteric artery, gangrene inevitably follows on their obstruction, and gangrene of the testis follows the closure of both spermatic and deferential vessels. The embolism causing gangrene is commonly

the result of endocarditis; the thrombosis may be general in its causation owing to the feeble circulation, or arise locally from disease of the vessel wall. *Obstruction of the abdominal aorta and the iliacs* may be due to detachment of clot from an aneurysm, or follow atheroma, or be caused by embolism. It may give rise to premonitory symptoms, often symmetrical, of intermittent lameness and paralysis, the intermittent lameness appearing after exertion with cramping pain, and clamminess of the extremities, which passes off on rest, or it may end in paraplegia. Gangrene may suddenly set in symmetrically at the end of any exhausting illness. Gangrene from rupture of a popliteal aneurysm, after or without ligature of the femoral, is not infrequent. An embolus in the axillary or brachial may cause dry gangrene of the arm below.

5. *Obstruction of smaller arteries, especially those of the leg.*—**Senile gangrene.**—The tibial arteries are narrowed by arteriosclerosis, following calcareous and atheromatous degeneration, thrombi form and gangrene commences, especially in the big toe. It is a senile change which occurs unduly early, and to a marked degree especially in patients who have suffered from Bright's disease, gout, diabetes, or syphilis, and is aggravated by alcohol in excess, also by overstrain. It occurs particularly in men. The arterial obstruction in the tibials may show itself before the onset of gangrene, by cramping pain, numbness, or clamminess of the feet, alternating with heat and tingling and formications. Pulsation is absent or imperfectly felt in the dorsalis pedis and posterior tibial arteries at the level of the ankle joint. The radial and temporal arteries may be found hard and tortuous. The patient may be suffering from cardiac hypertrophy, high pulse tension, albuminuria, diabetes, or obesity. The gangrene generally starts in the great toe beside the nail, in connection with some trivial lesion—a crust of dirt, a blister, a corn shaved off too deeply, an in-growing toe-nail, a bruise from the toe being stepped on, or a nail projecting from the sole of the boot. A dry dusky patch forms on the toe which becomes slightly swollen, red, and œdematous. The scab may fall off, and a chronic unhealthy ulcer deepen to the bone, and set up necrosis, or dry gangrene spreads to the foot and leg, not continuously, but intermittently, a line of demarcation forming imperfectly at each stage in the progress. Less often in cases markedly affected by the above conditions, *e.g.*, alcoholism, there is rapidly spreading moist gangrene.

Arteritis or endarteritis obliterans is an exceptional disease arising in relatively young patients, and is not caused by syphilis, alcoholism, gout, etc. It consists in a concentric or eccentric thickening of the inner coat of the vessel, is of unknown causation, and may be followed by thrombosis and gangrene. The disease tends to become arrested spontaneously.

6. Gangrene caused by *spasm of the arterioles* may be the result

of cold, frost-bite, carbolic acid or the ingestion of ergot, and is a special result of Raynaud's disease.

Gangrene from ergot.—Among the poor peasants on the Continent, who, after a wet harvest, live on ergotised ryebread, ergotism followed by dry gangrene may occur, but it has not appeared in this country during the last two centuries, nor is it caused by the use of ergot as a drug.

Gangrene due to frost-bite may be brought about (1) by *direct* action of intense or long-continued cold, the tissues being killed outright, or (2) *indirectly*, by the violence of the inflammatory

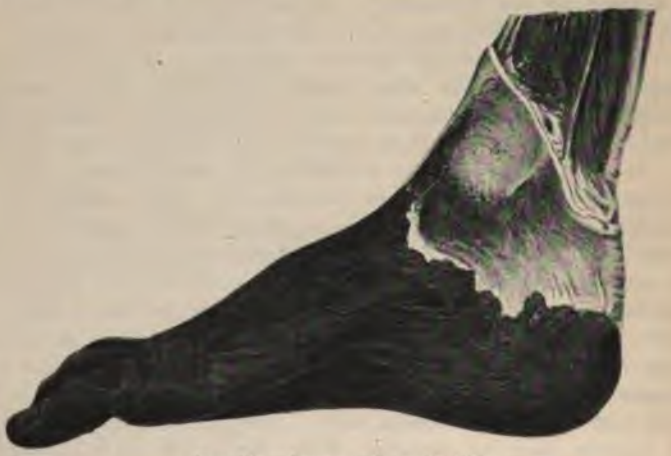

Fig. 12.—Gangrene from frost-bite.
(St. Bartholomew's Hospital Museum.)

reaction that ensues on the restoration of the circulation in tissues whose vitality has been lowered by previous exposure.

In this country frost-bite is comparatively rare, but is occasionally met with during severe winters in poor, half-starved, or debilitated subjects, especially in those whose constitution has been undermined by alcohol. The parts commonly affected are those in which the circulation is sluggish, as the toes, fingers, nose and ears. The part first appears blue and congested from the retardation of the blood due to the contraction of the vessels, then white as the circulation completely ceases. The feeling of intense cold now passes off, the part becomes numb and insensitive, mortification occurs, and the tissues become black, shrivelled up and dry, and a line of demarcation slowly forms (*dry variety*). (Fig. 12.) Or, if on cessation of the exposure the part is not actually dead, as the circulation returns acute inflammation, which is attended with severe burning pain, is set up, and this again may lead to compression and thrombosis of the vessels and end in gangrene (*moist variety*). An endeavour

should be made to restore the circulation, but so slowly as not to set up too violent a reaction. Thus the part should be gently rubbed by the hand with snow or cold water, and then wrapped up in cotton-wool, the patient being kept away from the fire in a cool room.

Carbolic Acid has frequently caused gangrene of the finger or toe when applied as a fomentation. It ought not to be so used except in weak solution.

Raynaud's disease is a peculiar form of spontaneous gangrene usually affecting symmetrically the fingers, toes, and more rarely the ears. It as a rule occurs in children or young persons who have previously suffered for a longer or shorter period from intermittent attacks of numbness and coldness of the extremities, generally brought on by cold weather (*local syncope*), followed later in many cases by blueness and congestion, accompanied by burning pain (*local asphyxia*), which, in its turn, shows a tendency to run into actual death of the part (*gangrene*). The gangrene is usually of the dry kind, but on the toes and shins a bleb may form, and the parts slough (*moist gangrene*). This condition is supposed to depend upon some disturbance of the vaso-motor nerve-centre inducing spasm of the arterioles, or in some cases upon a peripheral neuritis, but no organic lesion has yet been discovered. Hæmoglobinuria is frequently observed in association with it. Some cases have ended fatally with apoplexy and uræmia. Shampooing in warm water, also the constant descending current, as recommended by Raynaud, or placing the parts in an electric bath, has been attended with good results before gangrene has set in.

Treatment of gangrene generally.—The *premonitory signs of gangrene* being noted, the limb of the patient, if in bed, is wrapped in cotton-wool and elevated. In patients who can move about thick stockings are worn by night as well as by day with mittens on the hands, also thick gloves, and large boots out of doors.

The circulation in the limbs is best improved by shampooing in warm water and by massage. Cold and damp, also the approach to a hot fire, must be carefully avoided, and attention is specially required to this on account of the defective sensation.

In cases of dry gangrene from *Raynaud's disease* and from *frost-bite* the dead part is kept dry and dusted with iodoform whilst separation goes on. Only quite late, and after the general condition of the patient has improved, should a very limited operation be done, confined chiefly to trimming up the stump.

In all other cases the limb must be removed by amputation well above the dead part, at a level so well supplied with blood that rapid healing is ensured, and this must be done at the earliest possible moment to avoid septic exhaustion and the consequent failure of the operation.

The most unfavourable is the moist spreading *symmetrical gangrene* in exhausted patients. Yet amputation must be done as the only hope of saving life. As Mr. Pearce Gould pointed out in connection with a case in which he saved life by amputating above the knee on both sides, an interval of a week intervening, it is essential to amputate early on the one side, so as to give the patient time to recover a little before the second amputation. Unfortunately, such patients are often too exhausted or too old for any amputation to be attempted.

Senile gangrene from arterio-sclerosis has recently been treated with more success than formerly by recognising that the essential factor is the occlusion of the arteries of the leg, and that, therefore, as Mr. Jonathan Hutchinson points out, the amputation must be through the lower third of the thigh. Previous lack of success was due to favouring moist gangrene by keeping the limb hot and wet in poultices, and by amputating just above the dead part, where the vessels were diseased and the tissues infected by organisms. The result was septic inflammation, sloughing of the flaps, necrosis of bone and death, either at once or after re-amputation. When the limb is amputated early through the lower third of the thigh, healing without complications may be anticipated.

Albuminuria, diabetes, or both combined to a limited extent, is no bar to success after the high amputation. In a number of cases not only has the stump healed and the patient recovered, but the albumin or sugar has been reduced to a trace or has disappeared. The shock is not appreciably greater as no blood need be lost and the patient is soon out of bed. A patient with commencing dry gangrene of the toe should have the foot carefully cleaned, the nails pared, the dusky patch dusted with iodoform, and the whole limb wrapped up in cotton-wool and kept elevated. Then the general health should be, if possible, improved, and cardiac and renal complications relieved. If there is glycosuria a suitable diet should be given with opium or codeia. With improvement in the general health, the dusky patch may separate and the ulcer heal. If part of the great toe is dead but there is no tendency for the gangrene to spread, active measures should be delayed until the general health has improved, when the stump is trimmed in a limited way. But if the gangrene spreads, whether continuously or intermittently, an amputation above the knee must be done. A surgeon on finding no pulsation in the dorsalis pedis or posterior tibial artery should never attempt a lower amputation. He can further assure himself of the arterial obstruction by exposing these vessels before commencing the amputation. Moreover, the calcareous vessels have been seen in outline in a skiagram. The diabetic or other treatment for complications should be continued after the amputation.

Spreading septic gangrene is probably the result of inoculation with gas-forming organisms at the time of the injury. But the

injury may be a mere scratch, hence the above term is better than the older one of spreading traumatic gangrené, although it may follow a compound fracture with crushing and extravasation of blood. The limb rapidly becomes swollen, cold, and of an earthy leaden hue; in a day or so the dusky œdema has extended to the elbow or knee; within two days it has nearly reached the shoulder or hip joint, and moist gangrene follows behind with marked septic intoxication. Amputation must be promptly done above the œdematous zone, at the shoulder joint, through the middle of the thigh. If the flaps are already infected they should not be united in the first place, but kept apart by filling the wound with iodoform gauze. Pre-existing disease, alcoholism, or internal injuries may complicate the gangrene and prevent amputation from being successful. But apparently hopeless cases may be saved, as in some of Walsham's, in which pus and foul serum ran out of the stump.

Traumatic gangrene is of common occurrence in surgical hospital practice. It may be the result of a severe injury, such as the crushing of a limb, whereby the tissues are killed outright or their vitality is so lowered that the blood extravasated from the wounded vessels is sufficient in addition to the lowering of their vitality to kill them (*direct traumatic gangrene*). Again, it may be due to the rupture of a main artery or vein, or both, without any lesion of the skin (*indirect traumatic gangrene*). The *symptoms* in these cases are as follows :—The limb is cold and swollen, its sensibility is lost or blunted, and the pulse below the seat of injury is indistinguishable. As the patient recovers from the shock of the injury the circulation may return and all may be well; or the vitality of the part may become completely lost, the skin discoloured, and the signs of mortification, already described, set in. Here the process is entirely a local one, and is dependent neither on constitutional disturbance, inflammation, nor septic agencies. But if the limb or affected part of the limb be not removed and sepsis prevented, septic products will gain admission and give rise to local inflammation and to constitutional signs of blood-poisoning. The *treatment* consists in amputation near to, but well above the gangrenous part as soon as the diagnosis is thoroughly established and the shock of the accident has somewhat passed off; but as long as it is doubtful whether the limb may not recover, the part should be handled with all gentleness, rendered thoroughly aseptic if possible, kept warm with cotton-wool, and placed at rest on a pillow, while stimulants should be administered and tight bandaging and splints avoided, as such might be sufficient to determine the death of the part. If there be a wound the strictest precautions must be taken to render it aseptic and keep it so. At times gangrene may be prevented by a timely incision and the evacuation of a large blood-clot, or the removal of a portion of a fractured or dislocated bone pressing on the main vessel.

INFECTIVE PROCESSES.

Under this head are included those diseases or conditions which are known or believed to be due to infection by micro-organisms, A general account of the infective processes is first given; afterwards the special diseases are described.

(A.) General Infective Processes.

I. **Septic processes.—Sepsis.**—Septic processes divide themselves into three groups, according as the patient is suffering:—

(*a.*) From absorption of chemical toxin products (*septic intoxication*).

(*b.*) From organisms in the circulation combined with the absorption of toxins (*septicæmia*).

(*c.*) From both the absorption of toxins and the presence of organisms in the blood, with, in addition, the formation of metastatic foci of inflammation and suppuration (*pyæmia*).

It is not possible to draw either experimentally or clinically a sharp distinction between these three divisions. Fluids supposed to contain only chemical products may on more elaborate examination show germs in various stages of activity. It is not easy to exclude the presence of organisms in the blood; they are more often detected now than formerly. The names also applied to these processes are various.

(*a.*) **Septic intoxication—toxinæmia—sapræmia**—causing traumatic and hectic fever and lardaceous disease.

The disease is the result of the continuous absorption of chemical substances derived either as excretions from living bacteria or from material composing dead organisms, or from the abnormal secretion or degeneration of cells and tissues. These substances are nitrogenous amido-bodies derived from proteid substances allied to the usual products of katabolism, uric acid, etc., and to the alkaloids obtained from plants. Some of the substances have been identified, and their chemical formulas found by analysis; others have been given names, sepsine, putrescine, cadaverine, etc., according to their source. Generically these substances may be classified as toxic or poisonous albumins, or more briefly as *toxalbumins* or *toxins*. The general effect set up by them when absorbed may be called septic intoxication, or, in view of the substances getting into the blood, toxinæmia or sapræmia. Clinically the process may be considered as one in which the organisms exist only at the focus of the disease, the production of the poisonous substances being chiefly at this spot, from which absorption takes place continuously but in a limited manner. The amount of absorption is therefore more or less uniform, and the resulting intoxication is proportional to the dose. Therefore the fever being treated, absorption is arrested and recovery ensues. Negatively,

organisms are not found outside the area of the lesion, nor in the blood, so that the blood is not capable of infecting an animal, although a sufficient dose of the toxins may set up in it intoxication.

But it is difficult to absolutely exclude the presence of organisms in the blood. Experiments on animals are liable to great variations owing to differences in susceptibility. It is also difficult or impossible to draw a distinction between the degenerative processes in cells and tissues giving rise to zymolysis, through unorganised ferments or enzymes, and the bacteriolysis, which results from multiplying organisms. Nor can it be said to agree with recent observations that the organisms in such cases are merely saprophytes and not parasites (see p. 59), an idea implied in the term sapræmia. *Septic intoxication* must therefore at present be regarded as in the main a clinical distinction, hardly capable of pathological confirmation. Organisms, especially pyogenic cocci, multiply locally but do not extend. They manufacture toxins which act poisonously as enzymes by zymolysis on cells and tissues, both locally and after absorption. The clinical results are known as *septic* and *hectic* fever and the general effect is obvious in the destruction of red blood corpuscles, *septic anæmia*, and the albuminoid degeneration called *lardaceous disease*. But similar enzymes can result from breaking down of blood and other cells, without organisms.

Varieties of *septic intoxication* or *toxinæmia*. These are :—

1. *Simple traumatic fever* is a slight degree of intoxication, mainly the consequence of the absorption of broken-down blood, which in a limited way occurs after subcutaneous injury, fractures, contusions and in wounds healing by first intention. Here the intoxication is primarily the result of mechanical cell destruction, apart from organisms. Yet if there is extensive destruction and much blood extravasation, organisms appear and promote more or less suppuration, *e.g.*, in a subcutaneous hæmatoma, or in a wound which appears to start on an aseptic course. When uncomplicated by germs, the fever is slight and transient, but may undergo some increase owing to an excitable nervous system.

Generally, there is only malaise, loss of appetite, a rise of temperature (not above 101° F.), and the pulse is not above 100. It comes on immediately after the accident, and if not complicated by organisms, tends to subside in about three days or less than a week. Should it continue it points to pyogenic complications.

2. *Septic traumatic fever.*—This was formerly so commonly the result of any wound that it was taken to be a necessary consequence. It is now known that this is neither inevitable nor entirely due to imperfect drainage, but to infection by pyogenic organisms, for with the observance of antiseptic and aseptic precautions it has become quite the exception after operations, although more difficult to avoid in the case of accidental wounds in which it is not easy to get rid of all the organisms after they have once gained access. In a severe case

the temperature rises from the time of the accident or operation to 102° F. or 103° F. On the second or third day the patient may have a distinct chill or rigor with an evening rise, followed by some remission of the fever in the morning; the pulse is frequent (110 or more), the skin hot and dry, the urine scanty and high coloured with urates, the tongue furred, the appetite lost, and the bowels confined; there may be headache or delirium. The process remaining local, about the sixth day free suppuration will set in, and if at the same time or before this the discharge can escape, whether by dressing the wound, removing some stitches, clearing a tube if one has been inserted, or in other ways re-establishing drainage, the symptoms subside, and the wound heals by granulations. If the absorption of septic products continues there will certainly be further infection spreading locally or into the blood and septicæmia will be established. In the course of recovery after the incision of an abscess, or when discharge is flowing freely from a serous or synovial cavity, it is easy for the drainage to become deficient owing to the narrowing of the external wound or to a block or kinking of the drain-tube, and this is the more likely to occur whenever the opening is not at the most dependent part of the cavity, and there is a *cul de sac* where the exudation may collect.

Amputation or other free removal of disease, *e.g.*, amputation for gangrene, or for ulceration or necrosis of bone, excision of a suppurating cyst or chronic abscess, will be followed by the immediate relief of the symptoms of septic intoxication.

3. *Hectic fever* is a common accompaniment of prolonged suppuration, the abscess not being adequately drained and decomposition taking place in its retained contents. It is a chronic blood-poisoning, due to absorption of toxins in small quantities over a considerable period of time. A chronic abscess whilst unopened and before bursting, however large, does not give rise to it, nor after the opening of a large abscess does it occur so long as the drainage is good. Hectic fever is characterised by a sharp evening rise of temperature, when the cheek is flushed and the skin dry, followed by profuse nocturnal sweating and a morning remission of the fever, which leaves the patient weak. There is besides loss of appetite, diarrhœa, and the urine deposits urates. The patient wastes, his face is pale and pinched in contrast with the flushed cheek, the eye is bright, the pupil dilated, the tongue red and dry at the edges, the pulse becomes quicker in rate, smaller in volume, and lower in tension. Hectic fever especially comes on in tuberculous disease; thus it may result from a local suppuration, or arise from the insidious development, without marked cough, of a pulmonary cavity in which decomposition goes on, or both the surgical lesion and the pulmonary may progress simultaneously.

The most effectual *treatment* will be the prompt removal of the cause of the suppuration, either by some topical measure or by

amputation of a diseased limb. Failing either of these, we must try to establish better drainage and prevent decomposition by frequent dressings. A nourishing diet suitable for a weak digestion, also stimulants are indicated. The sweating should be checked by dilute sulphuric acid or by atropine, the diarrhœa by catechu, opium or other astringents.

4. *Lardaceous or amyloid disease* appears especially in the liver, spleen, kidneys, and intestines, less often in other organs, following upon long-continued suppuration, especially of bones or joints, in old-standing tuberculous or syphilitic disease. A nitrogenous material (not a carbohydrate as was first supposed, and hence the name amyloid) is derived probably from the degeneration of pus and tissue cells at the site of suppuration, and is carried thence by the blood stream. It is especially at first deposited between the fibrillæ of the connective tissue in the coats of the smaller arteries. The organs later appear infiltrated by a homogeneous opaque, glistening substance, comparable to bacon or lard or wax, which yields characteristic chemical reactions. It turns a dirty brown on the application of tincture of iodine, which changes to blue when sulphuric acid is added, whilst methyl violet turns it red. The liver and spleen especially enlarge, and may reach even to the iliac crest. The kidneys being affected the urine is of a low specific gravity, pale and excessive in quantity, and contains much albumen, also hyalin casts. The implication of the intestines sets up diarrhœa.

Only the removal of the cause, *e.g.*, by amputation, is effectual. As a result, if not too far advanced, the liver may shrink again, the albuminuria cease, and the patient get well.

(*b*) **Septicæmia — Bacteriæmia.** — In septicæmia there is a continual production of toxins either directly excreted by the organisms or indirectly formed by zymolysis kept up by enzymes derived from these organisms. And this takes place not only at the focus of the inflammation, but after extension in the neighbouring tissues and glands, and beyond them in the blood, and in internal organs. There is bacteriæmia in addition to toxinæmia. Thus, even if the local mischief is arrested, the organisms and their enzymes, which have passed into the blood, keep up the process, which thus becomes a struggle between the general resistance of the patient and the toxins produced.

It is the infection with streptococcus pyogenes alone, or mixed with staphylococci, which most commonly results in septicæmia, as, for example, in erysipelas, cellulitis, puerperal fever, the septic complications of scarlet fever and diphtheria, Ludwig's angina and post-mortem wounds. In all these cases the organisms have come from without, and being inoculated on a suitable soil, they grow so virulently, and produce such an amount of toxins that the patient's resistance, although previously he was in good health, is speedily overcome. The above-named conditions

illustrate the manner of the infection. A post-mortem wound causes inflammatory symptoms within a few hours of its occurrence, indicating how rapid is the multiplication of organisms from a virus carried in by a small prick. Extension follows by direct continuity, along tendon sheaths, or by lymphatics to lymphatic glands. Worst of all, there may be but little local signs, but rapid constitutional poisoning. Similarly, in puerperal fever the extension is rapid from the placental site through the uterus to the lymphatics of the broad ligament, or to the peritoneum. In erysipelas, extension is mainly by the skin in slighter cases, in more severe also by the cellular tissue. In septic pharyngitis, also after scarlet fever or diphtheria, there is rapid extension from the fauces to the connective tissue of the neck and the lymphatic glands, and thence a general infection.

The *symptoms* of septicæmia vary in severity in the following order:

Head symptoms.—Headache, nocturnal wandering, delirium, stupor.

Gastro-intestinal.—Loss of appetite, nausea, vomiting, constipation, diarrhœa. The *tongue* is moist with thick fur, a brown fur with crusts, leaving on separation a red surface; or it is a dry brown, shrunken, and fissured, with dry brown scales or sordes on the lips.

The *temperature* sometimes rises with a distinct chill or rigor to 103° or 104° F. or higher, generally without marked remission, but falling lower, even to become normal or subnormal before the patient's death; on the other hand, the temperature may quickly rise above 105° F. shortly before death.

The *pulse* increases in rapidity and loses in tension as the patient gets worse, and the rate exceeds 130 as the condition of the patient becomes grave.

The *face* at first flushed, gradually assumes an anæmic, earthy, sometimes distinctly jaundiced look, and becomes more and more shrunken. The skin is covered by a rash, either erysipelatous or scarlatiniform in type, or of an anomalous patchy character. At first it may be dry and hot; later clammy, moist and cold, with petechiæ and yellowish discoloration from blood breaking down.

The *spleen* is often felt to be enlarged. The *urine* becomes albuminous, and towards the latter end more and more scanty.

Pathological changes found post-mortem.—Rigor mortis is feeble, cadaveric lividity pronounced, decomposition occurs very rapidly. The blood is of a dark colour; the red blood corpuscles have undergone rapid disintegration, causing a staining of the tissues and skin. Petechiæ are found not only on the skin, but form capillary extravasation on the surfaces of serous membranes. The gastro-intestinal canal, the viscera generally, and the central nervous system show signs of congestion. The spleen is enlarged and pulpy, and the kidneys are markedly enlarged and congested. The lungs are congested and pneumonic, with blood-stained serum in the pleuræ. Organisms, especially pyogenic forms, are found in the blood and viscera.

Treatment.—The methods of treatment are local and general. By the local arrest of the process, at the chief manufactory of the poisons, the patient's general resistance may be able to overcome the systemic infection. The local treatment of a post-mortem wound,—free incisions, etc., for cellulitis,—in desperate cases amputation of a limb,—in puerperal fever, the curetting of the uterus and swabbing it out with antiseptics,—the painting of a sloughing ulcer of the fauces with a strong antiseptic, are instances. Partial relief may thus immediately follow, and the patient gradually recover.

The only general treatment of service is the administration of anti-streptococcus serum injected in 10 cc. doses into the subcutaneous tissue of the loin. At least four doses should be given within twenty-four hours. Extraordinary improvement follows in pure infections by streptococci, and no harm, even if no good, is caused except perhaps some urticaria around the puncture.

Failing this, the patient must be supported by fluid nourishment and stimulants. It is remarkable how much of the latter can be taken with a good result. Champagne or brandy may be given in small amount every half hour or hour, stopping short of producing symptoms of alcoholic intoxication. Large doses of quinine, 5 grains every two or three hours, until quinism supervenes, may be of value at the commencement. Later it is not worth while to upset the patient by drugs.

(c) **Pyæmia. — Metastatic infection.** — The name pyæmia, although first used on the mistaken idea that it was pus which passed into the blood, is well understood as implying the formation of metastatic inflammation and abscesses. In pyæmia the local production of toxins at the original site of infection and their absorption, septic intoxication, or toxinæmia, is combined with the production of further toxins, septicæmia, by the organisms which have reached the blood, bacteriæmia; and, further, organisms are carried by the blood stream and settle down in one or many places, there starting a new local production of toxins at a distance from the site of the primary infection. This metastasis seems to be especially brought about by the thrombosis of veins communicating with the primary area of infection, which thrombi, being invaded by organisms, suppurate, soften, and break down, and are then carried away as emboli to lodge in and thrombose capillaries at a distant spot, and give rise to a metastatic abscess. Septicopyæmia or pyosepticæmia or simply pyæmia is especially frequent after septic inflammation of bone. Thus, in septic disease of the temporal bone following otitis media the lateral sinus becomes thrombosed, then the clot breaks down and is carried into the circulation; again, in acute septic inflammation of the lower end of the femur, the large venous branches from the bone going to the superficial femoral vein become blocked, and then the thrombi break down. In puerperal

infection at the site of the placenta, the uterine venous sinuses and uterine veins become thrombosed and then suppurate, so that broken-down clot gets into the vena cava. Pyæmia also follows septic injuries to the skull, compound fractures, neglected thoracic empyema with necrosis of ribs, and abdominal abscesses. It may follow genito-urinary affections and intestinal lesions, such as dysentery, appendicitis, typhoid fever, rectal lesions. Of vascular lesions malignant endocarditis is a special cause. Pyæmia is now a rare consequence of wounds, but was a common complication prior to the introduction of aseptic surgery.

It is apparently the staphylococcus pyogenes in various degrees of virulency which plays the most prominent part in pyæmia, although there is often a mixed infection with streptococci and also other organisms.

Metastatic abscesses may form in any parts of the body; they are common in the subcutaneous tissue and in joints. They occur on the surface of the lung, where they may burst into the pleura and set up empyema; in the liver or spleen from gastro-intestinal absorption; in the kidneys; in the brain.

The pus is generally non-odorous, but may be contaminated with a fœtid bacillus, *e.g.*, the bacillus coli communis. Typically it is thin, watery, or oily, many of the pus corpuscles having broken down. It contains organisms, especially staphylococci.

When pyæmia has originated from a wound, the wound is found to be foul, with septic infiltration around and necrosis of bone; in particular the veins are thrombosed, and the thrombi are undergoing suppuration.

The stages of septic thrombosis in veins followed by metastasis can be especially well traced in ear-disease: (*a*) pus in the middle ear and mastoid antrum, but the lateral sinus and groove sound; (*b*) necrosis of the temporal bone, with pus in the lateral sinus groove, the wall of the sinus inflamed externally, but the interior unaltered and the lumen patent; (*c*) the wall of the sinus thickened by septic inflammation, the inner surface rough, and a clot blocking the sinus but not breaking down; (*d*) the sinus containing pus from breaking down of blood-clot where in contact with the middle ear, whilst below, extending down the jugular in the neck, is a firm clot with only slight inflammation and tenderness of the venous wall; (*e*) the clot in the jugular breaking down and its passage into the circulation marked by the onset of severe rigors; (*f*) or thrombosis followed by suppuration extending backwards against the stream up into the cerebral sinuses, and infecting the brain and meninges.

A venous branch becoming thrombosed, the clot projects into the lumen of the trunk that the branch joins, from which particles are detached and carried away by the stream (Fig. 13). The emboli, formed by the breaking down of the clot, sometimes

lodge in the superficial capillaries of the lung, and so cause septic pneumonia or empyema; or in the lobules of the liver, and cause multiple abscesses in that organ. But in other cases the emboli pass through the pulmonary and hepatic capillaries without leaving a trace, to lodge at some distant spot. An extension backwards down the veins and lymphatics of the lower limb is frequently seen after puerperal fever and other pelvic inflammations.

Some have distinguished two kinds of emboli: (1) particles of broken-down clot with organisms, likely to lodge in passing through the pulmonary capillaries; (2) emboli of micro-organisms only which are able to pass more easily through the pulmonary capillaries, and so get into the systemic circulation before forming metastases, then lodging in some capillary and producing a thrombus around. In some cases the emboli first lodge on the valves of the heart and set up malignant endocarditis, from which secondary septic emboli may later on be given off; a detachment of secondary emboli may also possibly follow small metastatic abscesses in the lungs.

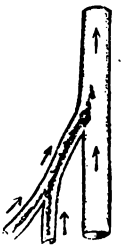

FIG. 13.—Thrombosed vein. The thrombus is seen projecting from the smaller into the larger vein.

Symptoms of pyæmia.—The characteristic sign of the commencement of pyæmia is a rigor. The most marked and severe rigors are seen in pyæmia, lasting an hour or more. The temperature rises rapidly to 103°, 104°, or higher, then falls with equal rapidity to normal or to subnormal. The patient during the rise has a pinched aspect, with cold extremities; during the remission he is pallid, earthy-looking, with profuse sweating and exhaustion. There is rapid wasting; the breath, also the body generally, exhales a peculiar sweetish odour. The tongue is red or glazed; later, dry, brown, and shrunken. The pulse is quick, becoming very rapid (170 or 180) during the rise of temperature and falling to 110 or 120 during the remission, and is of a low tension. The urine is albuminous. As in septicæmia, there may be extravasations into the skin, giving rise to petechiæ and eruptions resembling purpura. Diarrhœa and delirium occur in the later stages shortly before death.

Meanwhile metastatic abscesses develop. Of these the patient may not complain, either because they are painless or because of the general exhaustion. They are only to be noted by a systematic examination of the patient from head to foot twice daily, whilst disturbing him as little as possible. Subcutaneous indurations quickly fluctuate; joint swellings, fluid in the pleura, pericardium or peritoneum, or enlargements of the liver and spleen, appear suddenly without warning, having been non-existent on the previous examination twelve hours before. With this the wound or other site of infection, as the middle ear, the uterine cavity, may be foul and suppurating, or dry, with the formation of only a little thin fluid.

The *post-mortem appearances* are those of septicæmia, with, in addition, purulent collections. The body is emaciated, the skin yellowish, earthy-looking, with subcutaneous extravasations. The serous membranes, vessels and tissues may show staining from breaking down of red blood corpuscles. The spleen, liver, and kidneys are enlarged and soft, organisms are found in the blood of these organs, and to a varying degree in the metastatic foci, especially pyogenic cocci. In the subcutaneous tissue are abscesses containing sweetish, often oily, pus; in the joints the pus may appear almost like turbid synovial fluid, containing only a few broken-down cells. In the ear there is extensive necrosis of bone, pus, often foul, in the lateral sinus, also foul pus in the cerebral membranes and the brain. In a long bone there may be foul pus, with necrosis extending up the medullary cavity or to the neighbouring joint, with veins thrombosed and suppurating. At the placental site in the uterine cavity may be a sloughing ulcer, the wall so soft as easily to yield to the finger; in the uterine sinuses broken-down blood-clot and pus; in the broad ligament and retroperitoneal tissues multiple abscesses. In the veins of the leg may be found thrombi breaking down, with collections of pus in the connective-tissue planes between the muscles; in the liver, spleen, kidneys, and brain multiple abscesses, and on the surface of the lungs minute abscesses rupturing into the pleura.

Chronic pyæmia.—Occasionally pyæmia runs a chronic course. The site of infection may be unknown, infection being cryptogenetic, or the wound whence the infection came may have actually healed. No rigors need occur. The metastatic abscesses show a predilection for joints. The patient may live for weeks or months in a chronic septic state with hectic fever, or very slowly recover after one or more relapses, with stiffness of one or more joints, the stiff joints showing irregular fibrous or bony ankylosis. Or finally death occurs from exhaustion, with albuminuria, lardaceous disease, or after the development of pulmonary phthisis.

Prognosis.—This is always grave. If the local process can be completely arrested, *e.g.*, in the case of the ear, uterus, or long bone, and only one or two superficial metastatic abscesses develop that can be opened, then recovery may ensue.

If the patient does not succumb early, overwhelmed by the intoxication, but survives until the metastases have developed, and these are incised, then improvement may follow. If, however, he has lived so far, and yet the primary or metastatic foci cannot be fully dealt with, further metastases will develop and the patient finally die exhausted.

Treatment.—The most vigorous efforts should immediately be made to stop the local process; *e.g.*, in the ear, in addition to local measures the internal jugular vein may be tied to check further absorption (see *Ear*). The cavity of the uterus may be curetted, antisepticised, and packed with gauze, great care being taken not

to perforate the uterine wall; in some cases, indeed, success has followed removal of the uterus. When the infection is in a limb, whether connected with the bone or joint, or in the subcutaneous tissue, a prompt decision is necessary. If there is extensive septic thrombosis, and the process cannot be summarily and completely dealt with by incisions, scraping, or excising the thrombosed vein, then amputation must be carried out. In acute septic inflammation of the lower end of the femur amputation may be necessary within four days of the onset if life is to be saved. Anti-streptococcus serum is of no service for staphylococci take such a very prominent part.

The patient's strength is supported by a fluid diet, stimulants, and quinine. In all chronic cases a change of air to the seaside or to a health-resort, or a sea-voyage is of great service.

Micro-organisms and their products.

The human parasites belong both to the vegetable and animal kingdom. The arthropods, such as the insects and arachnids, live on the skin; worms in the intestine, or, during their cystic stage, in the deep organs and celullar tissue, or in the blood-vessels and lymphatics. Protozoa, such as the plasmodium malariæ, also live in the blood. But it is the vegetable parasites, the protophytes, belonging to the order of schizomycetes, which are of chief importance, and in connection with which the term micro-organism is chiefly used; the hyphomycetes or moulds, and the blastomycetes or yeasts, being found mainly on the skin and in mucous cavities.

Micro-organisms.—Schizomycetes or bacteria.—These are plants or protophytes, without chlorophyll, unicellular, but by growth and multiplication loosely united in various ways. They are divisible into three groups: (1) Cocci, (2) Bacilli, (3) Spirilla.

1. *Cocci* or *micrococci* are more or less spherical in form, like berries. They may be linked in twos, *diplococci*, in fours, *tetracocci*, or arranged in packets, *sarcinæ*, or like a string of beads, *streptococci*, or in a bunch like grapes, *staphylococci*.

2. *Bacilli* are seen as short or long rods, becoming spindle or club-shaped in sporing, or forming long threads, *streptothrix*.

3. *Spirilla* are threads coiled like a spring or corkscrew.

Whilst all bacteria have a typical form and are generally monomorphic, variation occurs under altered circumstances, giving rise to polymorphism, which may make identification difficult. In some this may be due to degeneration or to spore-formation.

Bacteria are composed of a proteid cell contents and membrane, called mycoprotein, and contain a nuclear or chromatin deeply staining substance, also osmic acid and iodine staining substances (fat, glycogen). They may have an external membrane of a cellulose-like material, forming a capsule.

Spontaneous movements occur in all bacteria except cocci, by means of whip-like threads, which contract and extend.

Division directly by fission occurs, leading to complete separation, or the organisms remain linked and run into long threads which later divide up into shorter ones. Under favourable circumstances this division goes on rapidly; cholera spirilla have been seen to divide every fifteen to forty minutes.

Spore formation takes place under various conditions; generally it is endogenous, the spore being liberated on the death of the mother cell, but in some cocci it is arthrogenous, spores are budded off, or the coccus changes directly into a spore, which has a more resisting covering. Hence, the destruction of spores by heat or chemicals is difficult. Since bacteria contain no chlorophyll, they must necessarily live on organic substances, like the yeast plant does. Some need free oxygen, obligatory ærobes; others flourish in the absence of oxygen, obligatory anærobes; a third class flourish in either according to circumstances, facultative anærobes or ærobes. Experimental bacteriology has identified and worked out the life-history of the various organisms by micro-chemical staining reactions, by cultivations in and on various materials and by animal inoculations. Organisms react differently to the influences of oxygen, carbonic acid, light, temperature, moisture, as well as to various chemical substances classed as antiseptics. By altering the conditions of artificial cultivation, or by employing the different susceptibilities of animals, organisms can be increased or diminished in virulence.

In the culture media in which the organisms are growing changes occur producing: (1) *Enzymes.*—Unorganised ferments arise in the organisms, which are in action proteolytic, diastatic, or inverting. (2) *Toxins*, also called *toxalbumins*, *ptomaines.*—Some have been identified and are substances having a definite chemical formula. They have various properties, harmful to cells and tissues by starting, to speak in general terms, katabolic changes in proteids. (3) *Antitoxins.*—Substances are produced which have the effect of neutralising the poisonous characteristics of the toxins, *e.g.*, as proved in the case of snake poison which is a chemical substance, or of checking the growth or of actually killing the bacteria themselves, germicidal or anti-microbic substances. These antitoxins are present in the serum of animals which have been inoculated with the organisms, and which have suffered to a certain extent from the disease produced by the organisms, but have recovered. Such animals no longer suffer when re-inoculated with the same organism. They are protected or immunised against the disease for a variable length of time. Serum taken from such an animal checks the course of the disease in another freshly inoculated, and serum from such immunised animals is now being used in the treatment of diphtheria, erysipelas, tetanus, snake-bite; whilst by the process of vaccination antitoxic properties are developed in the human blood sufficient to resist for a variable length of time infection by smallpox.

Micro-organisms are *saprophytes* only, or are *pathogenetic parasites.*

Saprophytic bacteria live on the surface and in the cavities of the body, or on a wound or in a sinus, deriving their nutrition from organic substances contained in the fluids found there ; but if they get into the blood or tissues they are quickly killed, and disappear without doing harm. They are only injurious when the fluids in which they live are not kept in movement but become stagnant ; then they can set up putrefaction. Putrefaction is the process by which dead organic material is broken up, the final products being carbonic acid, ammonia or free nitrogen and water. It is brought about by the action of organisms, is essentially a process of oxidation, and goes on freely when oxygen is abundant. Whenever the supply of oxygen is limited, half-stage products of the oxidation of proteid substances result, bodies of the class to which urea and uric acid belong, in which the nitrogen is in the form of an amido compound, a group of substances in which also the poisonous alkaloids of plants are included. When saprophytes thus set up decomposition in retained stagnant fluids, toxins, ptomaines, or toxalbumins are formed, which being absorbed into the blood are harmful, and a cause of cell and tissue degeneration and inflammation. The influence of the saprophyte is got rid of by putting an end to the retention. The retention of milk in the mammary gland leads to its decomposition, which then excites inflammation ; the same applies to the decomposition of urine in the bladder. Pus discharging by a sinus may contain the bacillus pyocyaneus, and should any temporary retention occur inflammation is set up.

Pathogenetic or parasitic bacteria.—Whilst these organisms can exist as saprophytes living on organic material, even within the body, without for the time doing harm, yet they are capable under favourable circumstances of living in the blood and tissues. They are infective for they enter the tissues and multiply, causing degeneration and death or necrosis, also cell proliferation. This they do by the toxins they form and excrete. Some organisms remain and develop at the site of inoculation, where their influence may be chiefly local, or may be generalised by the toxins passing into the blood, *toxinæmia*, *toxæmia* or *intoxication*, also *sapræmia*. Instead of remaining at the site of inoculation, the organisms may spread to the neighbourhood or along a mucous tract, or enter the lymph or venous stream. They may be stopped and destroyed in the lymph glands, or the organisms themselves may reach the blood, *septicæmia*. In the blood they may be destroyed, *e.g.*, be deposited and destroyed in the spleen, be excreted, *e.g.*, by the kidneys ; or multiplying be carried to some distant part (*metastasis*). There they settle down again and reproduce the inflammation, *pyæmia*. From the maternal circulation they may pass into that of the fœtus.

The activity of pathogenetic organisms may increase by the lack of resistance of the patient ; on the other hand, their virulence may slacken, whether by the production of antitoxins or by the digestive

action of phagocytes ; or they may continue partly active, as a chronic inflammation, or become latent, encapsuled, still retaining the power of recurrence, of relighting the inflammation. Difficulties in connection with recognising and treating the particular organisms may occur owing to one infection preparing the way for a second, or there is a double or mixed infection, as is frequently the case with pyogenic organisms.

(B.) Special Infective Diseases.

Pyogenic Infection.

(*a*) **Staphylococcus infection.**—*Staphylococcus pyogenes* (Fig. 14) is a spherical coccus, 0·9 μ in diameter, which may exist singly, or, when rapidly multiplying, two may be linked together. The cocci collect usually in clusters, hence the name *Staphylococcus*. When

Fig. 14.—Staphylococci. × 950. (After Sternberg.)

Fig. 15.—Streptococci. × 1000. (After Sternberg.)

grown in a culture-medium whitish colonies arise, which in contact with air turn mostly orange, *Staphylococcus pyogenes aureus ;* other varieties remain white, *Staphylococcus albus*, or yellow, *Staphylococcus citreus*. It is along with *Streptococcus pyogenes* the chief originator of suppuration, by giving rise to toxins, as shown by the poisons produced when it is grown in broth. It is found everywhere, in the dust and dirt of rooms, on the skin of the hands and other parts of the body, on instruments and apparatus wherever there are irregularities of surface and rust or grease. It exists hardly at all, or in a very inactive state, in fresh air, in good drinking water, and in sea water. Its presence may be detected by staining with various anilin dyes, including the method of Gram, by cultures on potatoes, in broth, on agar, etc., and by inoculating into animals, in which case a pure culture tends to set up a circumscribed abscess in the connective tissue. A culture rubbed into the intact surface of the forearm causes a boil or a carbuncular inflammation and suppuration.

Animals vary as regards susceptibility; horses, dogs, and cattle are specially susceptible; guinea-pigs and mice are less so. Its virulence gets rapidly less in cultures. By local inoculation or by rubbing into the intact skin, staphylococcus produces eczema, acne, boils, carbuncles, and subcutaneous abscesses. By infecting wounds it sets up inflammation, suppuration, and keeps up ulceration. Extending by lymphatics, especially when mixed with streptococci, it causes suppuration in the corresponding lymphatic glands; on reaching by way of veins or lymphatics the blood, it causes septicæmia and pyæmia. Metastatic suppuration arises in serous cavities, in the pleura, peritoneum, meninges, and in organs, the brain, liver, or spleen. Septic arteritis and endocarditis, and septic embolism may also be caused by it.

Some of its infections are cryptogenetic, the point of entry being unexplained, or it can remain latent in the circulation until a suitable nidus arises. This is especially noteworthy in acute septic inflammation of bone (periostitis, epiphysitis, osteomyelitis), which is an unmixed infection by staphylococci.

Occasionally it is the origin of a chronic infection, chronic septicæmia or pyæmia, with recurring metastatic formations, *e.g.*, recurring boils.

The organism may lie latent at the site of old suppurations for a long period, *e.g.*, in a cavity of a bone for twenty-five years, and yet prove itself still capable of setting up suppuration.

It has not yet been possible to obtain an active antitoxin from staphylococci; but Prof. A. Wright has reported good results in chronic furunculosis from staphylococcus infection, by the injection of portions of the sterilised culture of organisms obtained from the patient.

(*b*) **Streptococcus infection.** — *Streptococcus pyogenes* is a spherical coccus, 1 μ in diameter, doubling itself and then growing in chains (Fig. 15), especially in a fluid exudation or culture. It grows in white colonies on gelatine or agar, and stains with anilin dyes, especially by Gram's method. It loses its virulence quickly on ordinary media, but less rapidly in human or horses' serum. It is especially active in its influence on mice and rabbits, less so on dogs and rats. Its characteristic effect is an œdematous or phlegmonous inflammation, generally, not always, going on to suppuration in deeper parts; on the skin it causes erysipelas, and on a mucous membrane the formation of a mucopurulent inflammation with a fibrinous layer on the surface. It can exist, however, in these situations without setting up inflammation.

Entering by the skin through a small lesion, streptococci take especially the line of the lymphatics, causing lymphangitis with œdema around, and œdematous swelling of the lymphatic glands. Spreading by the skin it sets up erysipelas, characterised by

marked dilatation of vessels and a sero-fibrinous exudation. Extending by the subcutaneous tissue, generally then as a mixed infection with staphylococci, it is a cause of cellulitis.

Whether existing latently in the vagina or on the skin of the genitals, or introduced on the hands or instruments of doctors or midwives, it causes infection of the placental site with a sero-purulent discharge, and thrombosis of the uterine sinuses, œdematous inflammation and suppuration in the broad ligaments, or by further extension fibrino-purulent peritonitis.

Reaching the circulation, it is especially the cause of septicæmia with metastatic œdematous inflammations and pyæmic abscesses, in organs such as the kidney. Its exact relationship to scarlet fever is uncertain; it has been affirmed that scarlet fever is due to a variety of streptococcus pyogenes; be this as it may, streptococci readily complicate scarlet fever by extension from the fauces, and the septicæmic condition started by puerperal and pharyngeal or other infections by streptococci may closely resemble in its course an attack of scarlet fever.

An antitoxin obtained from streptococcus cultures has been extraordinarily successful in streptococcus infections, but only apparently when the infection is a pure one, and not, as is so often the case, when mixed with staphylococci. Then the streptococcus antitoxin is of no service.

Erysipelas and cellulitis. — *Cutaneous erysipelas* is due to practically an unmixed infection by streptococcus pyogenes—is, in fact, a streptococcal dermatitis. In *cellulo-cutaneous erysipelas*, and more markedly so in *cellular erysipelas* or *diffuse cellulitis*, in which the infection involves the subcutaneous and intermuscular connective tissue, staphylococci are also largely present, but the process is a mixed infection. Erysipelas and cellulitis constitute an infective, diffusely spreading inflammation of the skin or subcutaneous tissue or both; also mucous membranes and submucous tissues near the skin, and by spreading, serous surfaces such as the peritoneum may become involved.

It is at its early stage a fibrino-cellular inflammation, the connective-tissue spaces becoming distended with a fibrogenous exudation which coagulates, and on mucous and serous surfaces forms a fibrinous membrane. Then suppuration follows in the wake of the inflammatory œdema.

Whilst the *cause* of erysipelas is the streptococcus pyogenes, the general view at present seems to be that there are varieties of the organism owing to external variations, but not amounting to distinct species. Fehleisen, who discovered the connection of erysipelas with streptococci, regarded the organism as a distinct species, *streptococcus erysipelatosus*, capable, after repeated cultivation, of reproducing typical erysipelas. Improvement having been reported when lupus and malignant tumours had been attacked by erysipelas, pure

cultures of the organism were inoculated into human beings, and after fifteen to sixty hours erysipelas commenced.

In most cases a small scratch, crack, or wound serves as the point of entry; in others an open sore having existed for some time, the erysipelas supervenes. *Idiopathic erysipelas* was so called because, especially in facial erysipelas, no traumatism was apparent. Three possible explanations are suggested: (1) that a slight crack or fissure has been overlooked; (2) that the organisms have passed into the skin by way of a sweat-duct or hair-follicle, aided by rubbing—this can be imitated by rubbing into the skin a pure culture; (3) that it is a metastatic inflammation, the organism having entered some point at a distance on the skin or mucous membrane, *e.g.*, the uterus, hand. In its slightest form the affection clinically appears as *transient* or *flying erysipelas*, occurring in patches in various parts.

Erysipelas is prevented from attacking operation and accidental

Fig. 16.—Cellulitis. Connective-tissue lymph spaces filled with streptococci.

wounds by aseptic and antiseptic measures (see *Wounds*); from attacking wounds in course of healing by similar precautions in dressing; also by isolating cases of the disease and by good hygienic conditions. Bad ventilation and drains, overcrowding, and general lack of cleanliness favour the existence of the organism, and it is only where these conditions are present that erysipelas appears.

The so-called predisposing conditions are those which diminish the resistance of the body to the attack of the streptococcus, such as cold, chronic alcoholism, Bright's disease, gout, diabetes, malignant disease.

Recurring erysipelas is now recognised as being due to the organisms resting dormant as spores in the deeper layers of the dermis, but capable of being revived by conditions, such as cold, which lower the resistance of the tissues.

Pathology.—The streptococcus pyogenes when inoculated multiplies and spreads by the lymphatic spaces and vessels (Fig. 16). It may do so mainly by the skin, or by the cellular tissue, or along the lymphatics, without any sharp line of demarcation existing between the several clinical forms.

If it spreads *by the skin*, the streptococcus is seen in the lymph

channels and spaces, causing inflammation, as shown by the redness and swelling of the skin. The naked-eye appearance corresponds to a marked dilatation of the blood-vessels of the corium, followed by an emigration of leucocytes and a serous exudation. In the epidermis a lymph channel between the epithelial cells is distended by exudation, then a vacuole is formed by the destruction of the neighbouring cells, the nuclei falling off into the vacuole. By an enlargement of the vacuole owing to increasing serous exudation, an elevation of the corneous layer of the epidermis, a vesicle, is produced. Meanwhile there is a marked collection of leucocytes around the dilated vessels in the papillæ of the corium, some of these invade the epidermis and become added to the fluid in the vesicle; others invade the subcutaneous tissue. The lymph-spaces of the corium and adjacent subcutaneous tissue are distended by exudation swarming with streptococci. The disease now takes one of two directions—resolution, or extension with suppuration.

In *resolution* repair takes place by proliferation of connective tissue and epithelial cells. Micro-organisms and débris of leucocytes and tissues are absorbed by phagocytes, and the fluid exudation drains away by the lymphatics. There soon follows a complete restoration, but streptococci may remain some time dormant, not dead, but still liable to resuscitate the inflammation.

In *spreading* to the subcutaneous tissues, *cellulitis* is set up, with a marked tendency to suppuration. In this case especially a mixed infection with staphylococci occurs. The lymph-spaces become crowded with streptococci and leucocytes, also the connective-tissue fibrils around tend to disappear and to be replaced by leucocytes. In the intermuscular tissue, when invading muscles, extension occurs by the perimysium enclosing the muscle bundles. After this the muscle bundles are invaded. There is rapid blurring and degeneration of the muscle fibre itself, then it disappears under the fluid exudation and invasion by leucocytes. There is a tendency for the exudation to coagulate into fibrin, also for the leucocytes to degenerate and become pus corpuscles. Each distended lymph-space thus becomes the focus for an abscess surrounded by inflammatory œdema, after which the separate abscesses rapidly fuse. Owing to the acuteness of the inflammation, portions of skin, or fibrous connective tissue belonging to the subcutaneous tissue, or fascia, or aponeurosis of muscles, die *en masse*, forming sloughs.

The post-mortem appearances are those described under septicæmia and pyæmia. Death is often occasioned by the septic intoxication, before the development of metastatic inflammation.

Clinical Varieties.—Erysipelas may be divided into—1, the cutaneous; 2, the cellulo-cutaneous or phlegmonous; and 3, the cellular or diffuse cellulitis.

1. **Cutaneous erysipelas** generally attacks the skin primarily, less commonly the neighbouring mucous membrane. It is a specific

infective disease affecting chiefly the lymphatics and lymphatic spaces, and is especially prone to occur in the region of the face and head. The symptoms are *local* and *constitutional.*

Local signs.—There is a vivid blush of redness, usually noted as starting from a wound, scratch, or pimple, and appearing either simultaneously with, or in some instances not till twenty-four or forty-eight hours after the onset of the constitutional symptoms. The blush has a great tendency to spread, or to suddenly subside at one part and attack another (*metastasis*). The spreading edge is sharply defined and slightly raised above the surrounding skin, whilst the subsiding edge fades off into the healthy skin. The surface is usually at first vividly and uniformly red, œdematous, and shining, the redness fading momentarily on pressure, and later becoming of a dusky hue. The patient complains of a stiffness and stinging heat in the part. In very acute cases the cuticle is raised into blebs by the exudation of serous fluid beneath it, and the nearest lymphatic glands are generally tender and enlarged. Where the tissues are lax, as about the face or scrotum, there is much œdema, but there is little tendency to suppuration, except in the scrotum where gangrene and sloughing are not infrequently met with. When the inflammation subsides, there is usually some desquamation of the cuticle.

The *wound* itself, if one is present, takes on an unhealthy appearance; it ceases to heal, the edges swell, the granulations shrivel, and the surface becomes dry.

The constitutional symptoms generally begin with a chill or rigor. The temperature suddenly rises to 103° or 104°, or higher, but it does not fluctuate as in septicæmia and pyæmia. The pulse becomes rapid, and there is headache, loss of appetite, furred tongue and constipation, or sometimes diarrhœa.

Terminations.—The cutaneous erysipelas as a rule gradually subsides, or when affecting the face may cease quite abruptly, with a sudden fall of temperature to the normal, and the patient recovers; or it may spread over a large area, and the patient sink into a low typhoid state, and die of septicæmia, especially when the subject of kidney disease or other visceral trouble. When about the head and face it may spread to the pharynx or larynx, and end fatally from œdematous laryngitis; or it may spread to the orbit, conjunctiva, lachrymal apparatus, nose, or ear; or to the bronchi and lungs; or it may attack the membranes of the brain and set up meningitis; or the peritoneum, and set up peritonitis. A persistent œdema leading to permanent thickening sometimes ensues in the face or eyelids. Tendon-sheaths or joints may become involved, leading to adhesions or ankylosis. Relapses are common.

Treatment.—The bowels should be opened by a smart purge (calomel, gr. v. c. jalap, gr. viii.), and subsequently perchloride of iron given in large doses (tinct: ferri perchlor: m. xl., glycerini ʒij.,

quartis horis). Slop diet is usually required at first, but if the constitutional symptoms assume a low type, the patient should not be too much depressed, and a stimulating plan of treatment is indicated. Thus, ammonia and bark, brandy-and-egg mixture, brandy, strong beef-tea, etc., are called for should the temperature run high, the pulse become soft, and the tongue dry and brown, or low muttering delirium set in. Locally, nothing answers better than dusting the part with equal quantities of oxide of zinc and starch powder, and enclosing it in a thick layer of cotton-wool. Painting the part with an aqueous solution of nitrate of silver (10 per cent.) is sometimes of service. When there is an unhealthy wound, means should be taken to render this aseptic; but strong antiseptics, as carbolic acid, must be avoided, as they cause too much irritation. Should there be any collection of pus, or other pent-up discharge, it must of course be let out, and the part efficiently drained. When a patient is attacked with erysipelas in a hospital, he should be removed to an isolation ward, and the greatest care taken lest the infection spread to other patients, as does scarlet fever. It was an old practice to draw a stick of nitrate of silver over the skin in front of the spreading edge of redness, and it was said that the erysipelas would not pass over this line. Since the teaching has been in vogue that the inflammatory reaction which follows the spread of the micrococci is salutary in that phagocytes destroy the micro-organisms, attempts have been made to set up inflammation in front of the encroaching organisms by painting the skin with tincture of iodine. Cases in which the disease is said to have been thus arrested have been reported. In severe cases antistreptococcus serum must be employed in 10 c.c. doses, repeated four times in twenty-four hours.

2. **Cellulo-cutaneous, or phlegmonous erysipelas,** differs from the preceding variety, in that it involves the subcutaneous tissue as well as the skin. It is probably always associated with a scratch or wound, and nearly always terminates in suppuration of the subcutaneous tissue and sloughing of the skin, but it may not penetrate beyond the deep fascia, unless this has been injured. It is most common in the intemperate, or those of broken-down constitution or the subject of visceral disease, and is especially frequent after a scalp wound or one on the hand.

Symptoms.—There is locally much more œdema and swelling than in the former variety, but the redness is less bright and not so sharply defined, and blebs or bullæ containing serum, which may be blood-stained, often form over the affected part. The pain, at first hot and tingling, soon becomes throbbing, and the swelling brawny, and should suppuration occur, boggy in places; whilst the redness assumes first a dusky, then a purple, and then a mottled hue; finally, dark-coloured sloughs form, but no pointing occurs. If an incision is made into the tissues, they are at first found infiltrated with fluid, and later look like wet wash-leather

from the breaking down of the cellular tissue into pus and sloughs. As the inflammation is more intense than in cutaneous erysipelas, so are the constitutional symptoms, though similar, more grave. At the onset there are often severe and repeated rigors. The fever assumes a typhoid character as suppuration sets in. The disease may *terminate* in resolution, but more frequently runs the course above described, and may end fatally from complications, broncho-pneumonia, septicæmia, pyæmia, with exhaustion, or hectic. It is most fatal when, as is so frequently the case, the patient is the subject of chronic kidney disease. Locally, it may lead to necrosis of bone, destruction of a tendon or joint, thickening of the part, or much scarring.

Treatment.—This must be both constitutional and local. A purgative should be given at the onset, and the patient placed on slop diet, which should be exchanged, when suppuration occurs, for concentrated nourishment with quinine, iron, and stimulants. Locally, lint soaked in hot boric acid lotion, with belladonna extract and glycerine, should be applied, and short incisions made early before sloughing has had time to take place, *i.e.*, as soon as the parts become brawny. A number of small incisions made parallel to the long axis of the limb are preferable to one long one. They should extend through the skin into the inflamed cellular tissue, the hæmorrhage, which is often free, being readily stopped, if excessive, by plugging with iodoform gauze, or like antiseptic material. Subsequently the wounds should be dressed antiseptically, well drained, and the sloughs removed from time to time as they form. Should diarrhœa set in it may be controlled by opium ; but this drug must be given cautiously when there is kidney mischief. In bad cases, where much skin has been destroyed or a joint irreparably damaged, amputation may ultimately be required, but should not, as a rule, be done whilst the disease is in progress.

3. **Cellular erysipelas, or diffuse cellulitis,** is an acute, infective, and diffuse inflammation of the cellular tissue due to streptococcus infection commonly mixed with staphylococci. It may occur in the subcutaneous or submucous tissues, in the intermuscular planes, in the cellular tissue of the pelvis or orbit, in fact anywhere in the body where connective tissue exists. It may be produced in various ways. Thus it may occur in the subcutaneous tissue after a scratch or puncture, particularly one inflicted in the post-mortem room ; in the pelvic cellular tissue after parturition or the operation of lithotomy ; and in the submucous tissue after an injury, as a sting of the throat by a wasp.

Symptoms.—The constitutional symptoms resemble those already given under the preceding varieties of erysipelas, and though they may vary in intensity they are generally grave and soon assume an asthenic type, as the septic products are absorbed from the decomposing sloughs. The local symptoms vary according to the part

attacked. When the subcutaneous tissue is affected they are similar to those of cellulo-cutaneous erysipelas, save that the skin is not at first involved, but is only slightly reddened or mottled; the parts, however, feel hard and brawny, and become boggy as suppuration occurs. Later the skin, as the vessels which supply it are destroyed by the pressure of the inflammatory exudation in the subcutaneous tissue, loses its vitality, and rapidly becomes gangrenous and sloughs.

The *treatment* is like that of cellulo-cutaneous erysipelas. Incisions should be made early, and stimulating treatment is generally required from the first.

(c) **Pneumococcus infection.**—The *pneumococcus* is a pathogenetic form of streptococcus which is generally found in human beings as an oval or lozenge-shaped coccus united in pairs and surrounded by a translucent capsule, and may be seen in chains or large colonies. It stains especially with gentian-violet. It is a question whether it exists as varieties, or whether the various pathological conditions it gives rise to are the result mainly of external factors. Typically it is the cause of a simple fibrogenous inflammation, as in acute pneumonia or pleurisy, but with a tendency in the latter case to go on to suppuration and form an empyema. Whilst many different organisms are found in empyema thoracis, yet the pneumococcus seems to be the chief virulent organism. In such an empyema there are masses of fibrin floating in the fluid, showing that the suppuration has occurred after the fibrinous exudation. But beyond this the pneumococcus has been found to be the cause of serous or fibrinous inflammation going on to suppuration in other serous membranes, the pericardium, peritoneum, joints and meninges, also in the mucous sinuses connected with the nose and ear, maxillary frontal and mastoid, also of gastritis and general infection. It enters by the lungs, and hence many of these suppurations are metastatic, following on pneumonia, broncho-pneumonia and pleuro-pneumonia, and the organism appears to be connected with the prevalent attacks of "influenza." It may probably set up a primary affection in the sinuses of the nose and middle ear, from which possibly in some cases metastases are derived. (See also *Pneumococcal Arthritis.*)

Venereal Infection.

Under this head are included gonorrhœa, soft venereal sore, and syphilis.

Gonorrhœa infection.—The primary specific cause of *gonorrhœa* is the *micrococcus gonorrhœæ* or *gonococcus*, which sets up an acute infective specific inflammation of mucous membranes, attended by a profuse muco-purulent discharge, which becomes complicated by other pyogenic organisms in the later stages. Whilst mostly a

venereal disease inoculated upon the urethral orifice and glans penis of the male, and the urethral and vulvo-vaginal orifice of the female, yet it can attack other mucous membranes, especially the conjunctiva, less commonly that of the nose and rectum.

The gonococcus (Figs. 17 and 18) appears generally in pairs, the adjacent sides flattened against each other. The organisms are found either free in the discharge, or included in pus cells, or in the superficial layers of the urethral epithelium. They are easily stained with anilin dyes, but are discoloured again by using Gram's method. They

Fig. 17. — Gonorrhœal urethritis (Ziegler). *a*. Fold of mucous membrane. *b*, infiltrated with leucocytes, *c*, and with distended blood-vessels. *d*. Desquamating superficial epithelium. *e*. The detached epithelial cells with leucocytes and gonococci composing the muco-purulent discharge.

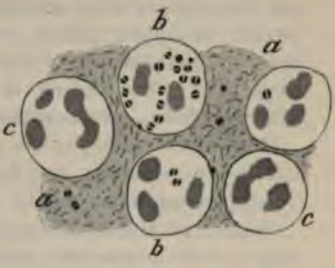

Fig. 18. — Gonococci (Ziegler). *a*. Extra-cellular. *b*. Intra-cellular. *c*. Polynuclear leucocytes.

can be cultivated only with great difficulty on agar and human blood serum, and with no degree of certainty in other ways. Animals are immune, but inoculation experiments on men and women done abroad have been followed by a muco-purulent inflammation. Clinically there can be no possible doubt as to the specific character of the inflammation at the commencement. Other pyogenic organisms, especially staphylococci, exist abundantly in the urethra and other lesions in later stages, and it is doubtful how far the general results of gonorrhœa are due to this mixed infection.

Pathology.—In the male the gonococcus usually begins to develop in the fossa navicularis, and thence spreads backwards along the urethra. It penetrates the surface layer of the epithelium and

lies partly between and partly in epithelial cells and leucocytes, where it multiplies. It extends, however, hardly at all through the epithelium to the sub-epithelial connective tissue in the case of squamous epithelium, but in the case of the transitional epithelium higher up this extension more easily takes place. There occurs a marked emigration of leucocytes from the vessels beneath the epithelium, which leucocytes, in travelling to the surface with the exudation, detach the superficial epithelial cells, whilst the mucous glands are stimulated to secrete. The urethral discharge therefore consists of mucous fluid in which pus cells, squamous epithelial cells and gonococci float.

The gonococcus can extend in the male backwards to the prostatic ducts, the vesiculæ seminales, the epididymis, and to the bladder; in the female to the urethra and bladder, the vagina, cervix and uterine cavity, the fallopian tubes, and through the abdominal ostia to the peritoneal cavity. It can enter the veins and lymphatics, get into the arterial circulation and set up endocarditis, or being carried to joints, bursæ, tendon-sheaths, and ligaments may give rise to inflammation, in which the organism may be found. With respect to other lesions, it is uncertain how far these are due to gonococci alone or to other pyogenic organisms.

Gonorrhœa leads to (1) a sub-epithelial connective-tissue formation and so to stricture, to (2) abscess around mucous tracts, and to (3) suppuration in glands opening on these surfaces.

Whilst at the commencement an acute process, it may subside into a chronic affection, attended by a local muco-purulent inflammation. But with the production of toxins, which may cause generalised chronic inflammation, especially in connective tissues, resembling rheumatism.

Inoculation.—Pus containing the gonococcus simply requires to be deposited upon a mucous surface; no lesion of the epithelium is necessary. Commonly this must occur in the male in the fossa navicularis; in the female in the vagina and about the meatus urinarius. Infection of the conjunctiva, less often of the nose and mouth, occurs during the passage of the child's head down the vagina, in children and adults by pus carried by the fingers, sponges, or towels. In little girls gonorrhœa is transmitted quite apart from attempted coitus by bed-linen, sponges and towels. To all *à priori* suppositions as to the possibility of gonorrhœa being evolved *de novo* in connection with dirt, it must be replied that such an event has not been proved to occur.

Summary of the clinical processes of gonorrhœa.—For details see Diseases of Regions.

A. *Primary seats of gonorrhœa.*—(1) In the male urethra causing muco-purulent urethritis.

(2) In the female urethra and vagina, causing muco-purulent

vaginitis and urethritis; in little girls, sine coitu, simply vulvo-vaginitis.

(3) In the conjunctiva (rarely nose or mouth), causing muco-purulent conjunctivitis.

(4) In the rectum, male or female, exceptional.

B. *Complications of gonorrhœa.*—I. Male. α. Local: 1, Balanitis, with or without paraphimosis; 2, posthitis, with or without phimosis; 3, warts; 4, intra-urethral hæmorrhage; 5, intra-urethral granulations; 6, stricture, (i.) spasmodic, (ii.) organic causing genito-urinary obstruction and its consequences; 7, chordee and occasionally induration of penis; 8, lacunar abscess, suppuration in Cowper's gland, perineal abscess and resulting penile and perineal fistulæ. β. Extension along the genito-urinary mucous membrane: 1, Epididymitis; 2, cystitis; 3, prostatitis; 4, vesiculitis; 5, rarely as an immediate result, pyelitis and nephritis, commonly after stricture.

II. Female. It is said to cause one-eighth of all "gynecological" disease. α. Local: 1, Urethritis; 2, vaginitis; 3, cervicitis; 4, abscess in Bartholin's gland. β. Extension along genito-urinary tract: 1, Metritis; 2, salpingitis; 3, pelvic cellulitis; 4, pelvic peritonitis; 5, cystitis; 6, pyelitis.

III. Inflammation extending by the lymphatics: 1, Lymphangitis; 2, glandular suppuration or bubo.

IV. General infection, so-called "gonorrhœal rheumatism": 1, Arthritis; 2, bursitis; 3, tenosynovitis; 4, inflammation of fascia (plantar) and ligaments of joints; 5, ocular lesions, conjunctivitis (simple, not the primary purulent), iritis, sclerotitis; 6, serous inflammations, endocarditis, pericarditis, pleurisy, peritonitis (hæmatogenous, not by extension); 7, septic infection, septic intoxication, septicæmia, pyæmia.

Soft venereal sore—due to infection with Ducrey's bacillus.—The sore forms a small irregularly circular ulcer or merely an excoriation from detachment of the epidermis, with sharply-cut, rather undermined edges, the floor covered with a yellowish-grey exudation, the base not indurated, a small red areola round the edge. An earlier stage, not often seen, except after inoculation on the skin, is that of a pustule. The exudation clears away from the floor, granulations appear, and healing follows.

The sores are often multiple, being usually placed on the corona, or surface of the glans penis and on the labia. They may be seen on the prepuce, or even over the pubes or on the inner side of the thigh, but not elsewhere except after distinct inoculation—either accidental or for purposes of diagnosis. The development of the sores is attended by much heat and itching, and by the formation of buboes, which as a rule quickly suppurate. But there is no general infection. The disease is now considered to be caused by the bacillus of Ducrey, which is constantly present. Scrapings from the sore scratched into the skin of the arm cause, after a day, redness; on

the second day pustules commence. Although other organisms are found in the sores, yet in the pustules resulting from inoculation only the specific bacillus grows and the inoculations can be repeated. The organisms are also found in the swollen glands included in leucocytes; they may be present in the pus and in the wall of the suppurating gland, but this is not always so; perhaps because they can be destroyed, and the gland undergo resolution.

A soft sore has to be distinguished from a hard chancre (see below). For diagnosis and treatment, see *Diseases of Genital Organs.*

Syphilis.—*Syphilis* is an infective disease, which, starting at the seat of inoculation, passes into the circulation mainly through the lymphatics, and then gives rise to inflammatory degenerating lesions. The common mode of inoculation makes it in the main a venereal affection, but it can spread otherwise (see *Extragenital Syphilis*).

Causation.—Syphilis is doubtless due to a specific organism. The analogies between its course and that of tubercle, etc., known to be caused by organisms is so close. It is as yet, however, uncertain whether the specific organism has been discovered. Lustgarten has described a bacillus, which some hold is distinct from the smegma bacillus, but at any rate it has not been cultivated. Further, no animal has been found to suffer from syphilis, nor can syphilis be inoculated into them, statements regarding the pig and monkey not being widely accepted. The discovery of other organisms, those causing soft sores, gonorrhœa, tubercle, leprosy, and pyogenic processes, have, nevertheless, greatly aided in differentiating syphilis. Whatever be the organism, there is abundant clinical evidence to show that it exists in the normal and pathological fluids, especially the highly cellular ones, in the secretions of mucous surfaces, in the urethra, vagina, and mouth during the primary and secondary stage, also in the blood, and in serous and purulent exudations, but especially in the sperm, apparently in the actual spermatozoon which fertilises the ovum.

Infection.—Generally speaking, a distinct local lesion is produced at the site of inoculation. Yet it is not necessary, especially in the female, for any local or indeed general lesion to be produced, for the child is infected from the very fertilisation of the ovum by the sperm, *conceptional syphilis.* The child being infected, the result on the mother may be a certain immunity to syphilitic inoculation, lasting during her pregnancy and for some time after childbirth (*Colles' law*). Presumably the child infected through the sperm produces an antitoxin, which confers this limited immunity on the mother. In some way also this immunity of the mother partially protects later children from becoming syphilitic, for they usually suffer in a diminishing ratio. An older explanation supposed a diminished virulence of the disease in the father. But against this latter explanation it has been noted that the eldest children of a second marriage have shown syphilis derived from the father, owing to the

mother not yet being immunised, like the first wife. In the case of a truly syphilised mother, all the children may be syphilitic; on the other hand, it is not necessary for a child to be infected either before or at birth, or to exhibit any lesion in later years, although both parents show evident signs of recently acquired syphilis.

The duration of infectivity cannot be stated with any certainty. An attempt to define this duration has been tried abroad by auto-inoculation of the patient, the inoculation of secretions into the skin being followed at first by a local lesion, and when this ceases to occur, the patient has been regarded as cured. But a patient who has ceased to be auto-inoculable may remain infective; as long as twenty years after acquiring syphilis a man has infected his wife. Usually, it is stated that after two years from the last manifestation, and after a full course of treatment, marriage is practically safe, but no great reliance can be put on this dictum.

FIG. 19.—Syphilitic or hard chancre (after Ziegler). 1. Epidermis raised by and infiltrated by cells. 2. Dilated capillaries. 3. Lymphatics distended with leucocytes. 4. Polynuclear leucocytes. 5, 6, and 7. Mononuclear, binuclear and multinuclear epithelioid cells derived by proliferation from connective tissue cells and giving rise to fibrous scar tissue.

Pathology.—Speaking generally, the syphilitic virus sets up chronic inflammation with tissue-cell proliferation, especially in connective tissue. This cell proliferation may terminate in scar tissue, or from insufficient blood supply undergo degeneration and necrosis. The following lesions are produced:—

(1) The hard chancre at the site of inoculation (Fig. 19) consists of a collection of leucocytes in the connective-tissue lymph spaces, along with a proliferation of tissue cells forming large epithelioid cells. Some of these cells now and again develop into a giant-cell, but not to the same extent as occurs in tubercle. It is these tissue cells which result in scar tissue, whether the chancre heal by resolution or after suppuration. At the same time the lymphatics become distended with small round cells, and the neighbouring lymphatic glands become swollen by inflammation.

(2) The secondary eruptions of the skin of the exanthematous type are the result of vascular dilation, without any important exudation, so that the rash quickly disappears, leaving no trace.

(3) The secondary papular and condylomatous manifestations result from a pathological exudation of fluid and a leucocytic infiltration into the papillæ of the corium and into the epithelium. The exudation saturates the epithelium, some of it coagulates, some of it escapes and makes the surface moist, the fluid being notoriously virulent.

(4) Pustulation and ulceration, also the ecthymatous and rupial eruptions, are the result of pyogenic organisms infecting collections

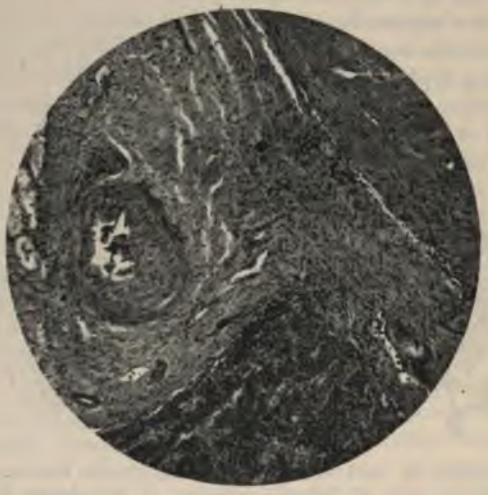

FIG. 20.—Photograph of a section through the outer part of a gumma of the liver. In the lower part the liver cells are seen partly obscured by inflammatory cells. Above this is fibrous tissue with elongated nuclei. In the left half is a blood-vessel the wall of which has been much thickened by syphilitic inflammation. In the upper part of the photograph the inflammatory tissue is undergoing myxomatous degeneration, the fibres and nuclei staining less deeply, and spaces between the fibres becoming distended by myxomatous fluid, and this degeneration is separated from the liver cells by a capsule of sclerosed tissue.

of leucocytes in the cutis and subcutaneous tissue, the resistance of which has been weakened by the syphilitic inflammation.

(5) A gumma is the characteristic formation of the so-called tertiary stage. It commences as a circumscribed inflammation in and around the blood-vessels of connective tissue. It is partly composed of emigrated leucocytes, partly also of proliferated tissue cells, which form young connective tissue and blood-vessels. If the fluid exudation is also marked the whole mass assumes a gelatinous consistency, having a greyish appearance, and tends to undergo myxomatous degeneration owing to deficient blood-supply; hence the name of *gumma*. If suppuration ensues from the invasion of pyogenic organisms, much of the tough fibrous connective tissue forms greyish wash-leather-like sloughs mixed with a sticky pus.

When, however, the connective-tissue proliferation gets the upper hand, scar tissue results.

(6) Besides gummata there occur changes in the later periods, which may be looked upon as continuations or relapses, especially marked by their persistent character. Instead of forming gummata, the inflammation results in the formation of fibrous tissue, *Sclerosis*.

Clinical forms of syphilis—These are best divided into (1) the local disease at the site of inoculation, and (2) generalised syphilis. But it is customary to divide the disease into (*a*) primary syphilis,

Fig. 21.—Photograph of a section through a breaking-down gumma of the testis. In the upper half is gummatous fibrous tissue which has undergone myxomatous degeneration, the fibres, and to a large extent the nuclei, no longer staining. In the lower half are tubules of the testis with inflammatory infiltration, myxomatous degeneration tending to advance among the persisting tubules.

the changes which occur at the site of inoculation along with lymphatic and glandular inflammation; (*b*) secondary syphilis, the earlier transitory and mostly more superficial lesions; (*c*) tertiary syphilis, characterised by the formation of gummata. But there is no line of demarcation between these forms, for it has been shown by the attempts to excise a primary chancre that secondary infection takes place very early. Gummatous eruptions also appear quite early in severe cases, whilst the so-called late secondaries may persist or reappear during the course of years.

Primary syphilis.—For the inoculation of syphilis there need be no lesion of the skin or mucous membrane, or merely a small abrasion which heals in a few days. Then there follows a latent period called the period of incubation, during which there are

no local signs, and which last for three to five weeks, when the primary sore or hard chancre commences to develop, followed by enlargement of the lymphatic glands.

Forms of chancre. — 1. *On the male genitals.* — The typical Hunterian chancre forms on the skin of the penis. Here, three to five weeks after exposure to infection, a slightly itching red spot is noted, which increases to an indurated papule, then to an area raised at its edges, so as to be sharply defined from the surrounding skin, but a little depressed in the centre. Its colour is dusky red, its surface glazed or covered with epithelial scales or dried serum. On raising it up between the thumb and finger (protected against infection by lint), it is felt to be resistant, painless, as if a bit of cartilage or parchment had been let into the skin, but movable on the deeper structures. There is no inflammation around, but the lymphatics running along the dorsum of the penis can often be felt as a fine cord, and the inguinal glands are enlarged, hard or shotty, forming an indurated bubo, but can be manipulated without pain. Mercury being given, this induration disappears by resolution, and there is left an area of skin a little whiter than the rest, with a zone of rather deeper pigmentation around. Later on this scar may undergo a gummatous change, the chancre being said then to recur. Being infected from without by pyogenic organisms, a chancre may ulcerate or become phagedenic. A hard sore may also develop on the margin of the prepuce, on the frenum owing to a slight rupture, or on the corona or at the meatus urinarius. The induration in such a case is marked but more diffuse, fading more gradually into the surrounding tissues; the surface is covered with a muco-purulent secretion, and ulceration much more readily occurs.

Less frequently the sore is seen at the root of the penis, on the scrotum, neighbouring thighs, mons veneris, or on the hypogastrium up to the umbilicus. In these cases generally some lesion of the skin, *e.g.*, parasitic, has been present beforehand.

Typically the Hunterian chancre is single, but it may be multiple, especially under the above conditions, when two, three or many chancres may develop at the same time. Moreover, a hard sore may co-exist with a soft venereal sore, or with gonorrhœa.

Occasionally a syphilitic sore affects the urethra further back than the meatus. Its course is then anomalous; it may or may not be attended by local and glandular induration, but it tends to result in a very tight stricture. When a man is inoculated by syphilis without any primary lesion being noticed, it is not unlikely that this occurs through the mucous membrane of the urethra. This would also explain the cases in which secondary syphilis follows a purulent urethritis, apparently gonorrhœal.

2. *On the female genitals.*—The sore is most commonly seen on the mucous surface of the labia; there the induration is not well

circumscribed, indeed it may rather consist in a general œdema of one labium. Less commonly there is a sore on the vaginal wall, in the neighbourhood of the urethra or upon the cervix uteri, but in the vast majority of cases chancres in these situations pass unnoticed. Less often a hard sore is found on the skin in the neighbourhood of the vulva, or anus, or inner side of the thigh, having been inoculated upon some previous skin lesion, and in these situations the sore may be multiple.

3. *Primary sore on the genitals, not inoculated during coitus.*—Without doubt, inoculation has taken place from sores on the fingers of practitioners or midwives, also through instruments used by them, but such accidents are nowadays inexcusable. Primary sores have been inoculated during circumcision through the instruments or saliva of a Jewish operator. The children showed an indurated wound, enlarged glands, well-marked secondary lesions and great wasting.

The possibility of inoculation of the genitals through external objects, linen, the seat of a closet, etc., may be admitted, but tales that syphilis has in this way been contracted must be regarded with great scepticism.

4. *Extragenital chancres.*—These are most common on the lips, less common on the inner surface of the mouth, on the tongue, palate or fauces, being inoculated from the saliva and ulcerated mouths of secondary syphilitics. If by kissing, then they are commonly seen on the upper lip in young girls. Pipes or musical instruments, or the mouthpieces used by glass-blowers, when passed from one to another have transmitted syphilis. Eating and drinking in common from wooden vessels and spoons is said to be the means of transferring syphilis to a very large extent in Russia.

Sores also form on the eyelids and other parts of the face, probably through infected saliva.

A sore on the finger has been acquired by practitioners and midwives during vaginal examinations, also from incautiously handling a sore. A foul little ulcer, which does not heal, is seen beside the nail or on the back of the finger above the nail, arising without any pain or induration. Syphilis has been directly inoculated in the course of vaccination, by clear serum taken from the arm of a child at the time not obviously syphilitic, an accident now prevented by the use of calf-lymph. Both a surgeon and his assistant inoculated themselves through finger-pricks during an operation. Surgical and dental instruments have transferred infection, for dried syphilitic material may remain virulent for months. A few well-established cases of inoculation from a cadaver during a post-mortem examination are on record.

When a syphilitic infant is put to suck a previously non-infected wet-nurse, a hard sore may form on her nipple, whilst the child's mother escapes (*Colles' law*).

Extragenital syphilitic sores ought to be generally diagnosed with ease. The sore is surrounded by more or less œdematous induration; there is practically always a marked enlargement of the corresponding lymphatic glands, submaxillary, axillary, etc., and a well-marked rash. The nearest resemblance is a vaccinia sore, which may be inoculated from a baby's arm to the eyelids, lip, or nipple, and has been even transferred to the vulva of the mother and thence to the penis of the father. Vaccinia is to be distinguished by inquiring into the history, noting the times of development and the characteristics of the sore, and the absence of a rash. In later life an epithelioma is distinguished by its slow development and the absence of secondary manifestations.

When syphilis is inoculated upon a previous wound there is an increased inflammatory induration and discharge, along with enlargement of the lymphatic glands and a secondary rash supervenes.

Generalised syphilis.—The so-called *secondary* symptoms consist of certain affections of the skin and mucous membranes, general enlargement of the lymphatic glands, especially the posterior chain in the neck, and more rarely of inflammation of such deeper structures as the iris and periosteum. They generally set in from six weeks to three months after the appearance of the primary sore. They may assume a very severe or a very mild form, or they may not occur at all, or may be so slight as to be overlooked. Some fever may attend the onset, the temperature rising, *e.g.*, to 101° F.

The *skin eruptions* may take various forms. The earliest to appear is usually a *roseolous* rash over the chest and abdomen. It is generally accompanied by a congested condition of the mucous membrane of the fauces, giving rise to a slight sore-throat. This rash is produced merely by superficial vascular dilatation, and hence fades on pressure, and usually disappears in a short time. But should the congestion continue, some infiltration of the skin by leucocytes occurs, and the epithelium takes on increased growth, and is thrown off in the form of scales, the eruption being then known as a *scaly* syphilide or *psoriasis*. Should further infiltration occur, a *papular* syphilide, or *lichen*, may be produced; or if the process is more acute, serum may be exuded, and raise the cuticle in the form of small vesicles, or even of large blebs, conditions which are spoken of as a *vesicular* syphilide or *eczema*, and as a *bullous* syphilide or *pemphigus* respectively. Both, however, are rare, and the latter seldom occurs, except in congenital syphilis. Still later, especially when the patient is debilitated, the vesicles may be converted into pustules (*pustular syphilide*), while the pustules again may dry into scabs, which fall off, leaving no scar beneath (*syphilitic ecthyma*); or if the patient is cachetic, or his constitution broken down, ulceration may ensue beneath the scabs (*rupia*). The appearance presented by rupia is peculiar. As the ulceration proceeds in depth and extent, larger and larger scabs are successively formed beneath those

above, which are thus pushed forward, giving the mass the appearance of a limpet-shell. Each rupial spot is surrounded by a dusky-red areola, and on the separation of the scab, a foul circular ulcer is left, which, on healing, leaves a permanent scar. Rupia by some is regarded as an early tertiary, by others as a late secondary affection. With the exception of rupia the eruptions in syphilis resemble those due to non-syphilitic causes. They are, however, all modified by their coppery or raw-ham colour, by more or less surrounding pigmentation, by their symmetrical arrangement, by the circular or crescentic shape of the patches, by the absence of itching, by the absence of the large silvery scales seen in ordinary psoriasis, by their predilection for certain situations, *i.e.*, the chest and abdomen, the space between the shoulders, the back of the neck, the forehead, especially about the roots of the hair, the palms and soles, and the flexor aspect of the limbs; and lastly, by their polymorphism, *i.e.*, their mixed character, the eruption being here papular, here scaly, here pustular, etc. In situations where the parts are moist, as about the mouth, anus, and scrotal folds, the papillæ become succulent and the epithelium sodden, forming *condylomata*. Where such occur between the toes, ulceration may ensue (*rhagades*); but this condition is not common, except as the result of uncleanliness. *Condylomata* appear as low, soft, flattened, sessile elevations of a whitish colour, with a smooth surface, covered by a moist secretion, and often of a considerable size. They are intensely contagious, and when occurring where two skin surfaces are in contact, as about the anus and labia, are usually symmetrically placed on either side. The affections of the *mucous membrane* are similar to those of the skin, and are also usually symmetrical. At first, they consist of mere congestions, later of infiltrations with overgrowth and soddening of the epithelium (*mucous tubercles*), and subsequently of superficial ulcerations from the breaking down of the infiltrating inflammatory exudation. Mucous tubercles are especially common about the palate and fauces, side of the tongue, lips, and cheeks, and appear as slightly-elevated, whitish-looking patches, giving the part somewhat the appearance of having been rubbed over with nitrate of silver. The ulcers, which occur in similar situations, particularly about the tonsils and corners of the mouth, are usually of a crescentic shape, with sharp-cut edges, and are quite superficial. Similar mucous patches and ulcers may occur in the larynx or about the anus or in the rectum.

During the later secondary stages, besides the superficial eruptions and ulcerations which may still be present, the deeper structures may become involved. Amongst these may be mentioned the iris, periosteum, bones, joints, ear, and testicle. The lymphatic glands, not only those nearest to the primary sore, but over all the body, become affected, the posterior cervical more particularly so. This condition is of service in diagnosis; but as it gives rise to no

symptom, it is generally overlooked by the patient. *Syphilitic iritis* is especially characterised by the presence of nodules of lymph on the iris, the effusion into the anterior chamber, the comparatively small amount of pain, and its amenability to mercurial treatment. But the irregular pupil, discoloured iris, circumcorneal zone of congestion, photophobia, and patches of pigment on the lens, are also present as in other forms of iritis. The *periostitis* seldom gives rise to the distinct nodes so common in the tertiary stage; otherwise the symptoms are similar. The *joint-affections* are like those in rheumatism, arthralgia, synovitis, hydrarthrosis, and exhibit nothing very characteristic. *Epididymitis* and *orchitis* are occasionally observed, and are then generally symmetrical, thus differing from the gummatous affections of the testicle in the tertiary stage.

The general health usually suffers, the hair becomes thin (*syphilitic alopecia*), and the patient anæmic. At times severe cachexia ensues, attended by much wasting and prostration.

Syphilitic anæmia is very marked during the early exanthematous stage in patients at the extremes of life, the young and old. There is both a diminution in the number of red cells and a reduction of hæmoglobin, also, as distinguished from chlorosis, there is a considerable degree of leucocytosis.

Gummatous syphilis.—The symptoms of the *tertiary* stage commonly occur after a period of apparent cure, sometimes within a few months after the cessation of the secondary symptoms, at other times not till after many years. Occasionally, however, they may be manifested within a few months of the primary sore, *i.e.*, during the period usually assigned to the secondary stage, and run a fatally rapid course. Moreover, between the termination of the secondary and the onset of the tertiary, certain skin eruptions, enlargements of the testicle, choroiditis, inflammations and ulcerations of the tongue, and psoriasis of the palms may occur, and have been spoken of as "reminders." They are by some regarded as constituting an intermediary stage. The tertiary affections proper are of a more serious nature than the secondary, and show no tendency to spontaneous subsidence. They depend upon chronic inflammations in various tissues and organs leading to the formation of *gummata*. The gummata undergo myxomatous degeneration and break down, producing when situated in the subcutaneous and submucous tissue characteristic ulcers; or they may continue for indefinite periods, or be slowly absorbed under appropriate treatment, leaving fibroid thickenings and scarrings in the capsules and substance of the affected organs. These gummata vary in size from a pea to a walnut, and are intimately blended with the surrounding tissues. They consist, roughly, of three zones; in the central, the cells are breaking down and undergoing myxomatous change; in the next zone the cells are contained in a fibrillated matrix; in the outer zone numerous vessels ramify among the cells.

The breaking down of the central portion is attributed to changes in the vessels causing a diminution of their calibre or complete thrombosis, whereby the blood supply of the central zone is cut off and degeneration consequently ensues. Amongst the most common of the tertiary lesions may be mentioned—1, chronic gummatous inflammation of the periosteum, commencing in the deeper layers of the periosteum, leading to the formation of nodes, caries, or necrosis of bone, and giving rise, as when attacking the bones of the nose, to horrible deformity; 2, gummatous infiltration of the skin and mucous membrane (*tubercular syphilide*) terminating in serpiginous ulceration; 3, gummatous swellings in the subcutaneous and submucous tissue, which may break down, forming deep ulcers, the cicatrisation of which causes severe contractions, as for instance those seen in the stricture of the pharynx, glottis, and rectum; 4, gummata in the muscles; 5, gummata in the tongue, producing scarring and ulcers apt to terminate in epithelioma; 6, gummata, followed by contraction and fibroid changes in the liver, lungs, brain, and other viscera. The various tertiary lesions will be further described under *Diseases of the special Tissues and Organs;* for those affecting the lungs, liver, kidneys, and nervous system, a work on Medicine must be consulted. Here it must suffice to say that the tertiary lesions are usually asymmetrical; that they are not, as a rule, contagious; that they are chronic in their course; and that they often prove fatal by affecting important organs, as the lungs or brain, or by causing constriction of a passage, as the larynx or rectum.

Syphilitic sclerosis.—This is most marked in the blood-vessel walls, causing thickening especially of the inner and middle coats, narrowing the lumen and so diminishing the blood supply, or so weakening the vessel wall that it dilates to form an aneurysm (which see). This sclerosis also affects intermuscular tissue, and the connective-tissue frame of the viscera, especially the liver, and kidneys. Also a chronic inflammation affects the skin and neighbouring mucous membrane, causing an hypertrophy of the epithelium so as to form raised patches covered with whitish epidermis. This is seen on the skin in various parts, especially the palms and soles; it is also met with on the tongue and inner surface of the mouth, and also on the labia. The same condition may arise from other causes, particularly in the mouth from smoking, and is liable to go on to epithelioma.

The *treatment* of syphilis necessarily varies according to the constitutional condition of the patient and the stage of the disease. The *primary sore* requires no other *local* treatment than the application of iodoform or black-wash and protection from irritation. Some, however, still advocate its destruction by caustics or complete excision, and further recommend removal at the same time of the nearest indurated glands. The majority of surgeons have long

regarded such treatment as useless, believing that the induration of the primary sore affords an indication that the disease is already established in the constitution. Excision has repeatedly failed to prevent the occurrence of secondary symptoms. *Constitutionally*, mercury in some form is by the majority of surgeons thought to be necessary in all cases. It must, however, be given with caution to anæmic, strumous and tuberculous subjects, and to persons whose constitution is impaired by dissipation, alcohol, or bad living. It should be withheld in chronic Bright's disease ; nor should it be forgotten that some patients exhibit a peculiar idiosyncrasy, in that they are violently salivated by a grain or two of the drug. Mercury may be given—1, by the mouth ; 2, by inunction ; 3, by fumigation ; 4, by intramuscular injection ; and 5, by intra-venous injection. It is, as a rule, perhaps, best given by the mouth, either in the form of a pill or mixture. As a pill, the green iodide in doses of gr. $\frac{1}{2}$ to grs. 2, combined with gr. $\frac{1}{8}$ to gr. $\frac{1}{6}$ of opium to prevent purging, may be given two or three times a day, or the mercury and chalk powder in doses of from grs. 2 to grs. 3, or calomel or blue pill may be substituted for it. As a mixture, the perchloride in doses of gr. $\frac{1}{32}$ to gr. $\frac{1}{16}$, combined with ammonia, is very useful. The green iodide possesses an advantage, in that the iodine prevents an accumulation of mercury in the system. Tannate of mercury is highly recommended by some surgeons, since, being unaffected by dilute acids, it passes through the stomach without change, but on reaching the duodenum is reduced by the alkaline secretions to its metallic state, the globules being so minute that they are believed to be capable of absorption by the villi. Hence it is less liable than other preparations to set up gastro-enteritis and diarrhœa, and having no cumulative properties there is less fear of salivation. It is rapidly absorbed and as quickly eliminated by the urine. The drug, moreover, is stable. It should be given in the form of a pill in doses of gr. $1\frac{1}{2}$. Where mercury given by the mouth causes much irritation of the bowels, it may be used in the form of an inunction, half a drachm to one drachm of mercurial ointment being rubbed into the inner part of the thigh or the side of the chest every night for four to six nights, the parts being thoroughly washed every morning to prevent the ointment accumulating in the sweat-ducts and causing pustules, etc. This is a rapid way of bringing the patient under the influence of the drug, as is also fumigation with calomel or other preparation of mercury, though this latter method is more uncertain and may be followed by violent salivation. The effects of the mercury should be judged by its action on the primary sore and secondary affections. Under its influence the induration of the sore rapidly disappears, and the rash fades. It should never be pushed beyond causing a slight soreness of the gums, the formation of a red line on their free margin, and tenderness on biting. Should salivation occur, the mercury should

be immediately stopped, a gentle purgative given, the mouth rinsed with a gargle of chlorate of potash, and iron taken internally. The mercury should also be intermitted for a few weeks or so at a time if symptoms of depression come on. During the mercurial course the patient should avoid chills and abstain from alcohol, fresh fruit, and food liable to disturb the digestion and set up diarrhœa. The mercurial course may with advantage be continued for a year or more, and on its termination iron, tonics, and cod-liver oil should be given, whilst change of air and the baths of Aix-la-Chapelle or Harrogate will be found beneficial. If mercury cannot be taken or is contra-indicated, iodide of potassium with a tonic treatment may be tried. Whenever a full course of mercury is to be carried out, the mouth and teeth require attention, the teeth are scaled or filled, stumps extracted, gums massaged and hardened by astringents. If the patient is anæmic and the ulceration spreading, the patient should be kept in bed, overfed (Weir Mitchell treatment), the iodide stopped, and only very small doses of mercury given. Should phagedena occur, it must be energetically treated by the continuous hot bath, etc. (see p. 34). During the *secondary stages* mercury should still be continued internally. Locally, condylomata are best treated by dusting them with equal parts of calomel and oxide of zinc, under which they dry up very rapidly; mucous tubercles about the fauces yield to gargling with black-wash; superficial cracks and ulcers on the lips, tongue, etc., may be painted with a lotion of bicyanide of mercury 1 in 1,000, or chromic acid 10 per cent., or mercury ointment may be rubbed in with the finger. Iritis should be energetically treated by mercury, or if this is already being given, the dose should be increased, whilst locally atropine should be dropped in the eye, and if there is much pain and the congestion is acute, leeches or blisters should be applied to the temple. In the *tertiary stages* iodide of potassium has the most marked effect. It may often be advantageously combined with ammonia, quinine, iron, or cod-liver oil, or even with small doses of mercury if the affection proves intractable. If badly tolerated, iodide of sodium or ammonium may be substituted for it. In tertiary nerve lesions intramuscular injections of perchloride of mercury (gr. $\frac{1}{8}$) or of salicylate of mercury (gr. $1\frac{1}{2}$) are strongly recommended. The following formula is used: Hydrargyri. ʒi., lanolini pur. ʒij., Ol. carbol. (2 per cent.), ʒi., maximum dose ♏x. The injections are usually made once a week or oftener in the glûteal region, the syringe being passed deeply into the underlying muscle. If blood flows, the needle should be withdrawn and re-inserted to avoid the danger of pulmonary embolism. In intractable cerebral syphilis, where there is great pain or a vital part is involved, intra-venous and para-venous injections of mercury have been attended with brilliant results. A ligature is applied above the vein selected, usually one at the bend of the elbow, the needle thrust into the vein, the ligature loosened, the syringe attached, and one gramme

to four grammes of a 1 per cent. solution of perchloride or cyanide of mercury injected. The strictest antiseptic precautions should be observed. The chief advantage claimed for this method is that it succeeds after all other methods have failed. In the para-venous method the mercuric solution is injected in the neighbourhood of the vein, but it causes pain and inflammatory reaction; the intra-venous injection is painless.

There are certain conditions which, though they follow upon and are believed to be a consequence of syphilis, do not yield to the fullest doses of iodide of potassium or to mercury pushed to salivation. These are spoken of as *post-syphilitic* or *para-syphilitic lesions.* As examples of such may be mentioned aneurysm, locomotor ataxia, and general paralysis, all of which are held to be, in men usually, and in women practically always, due to syphilis, and sometimes appear in the young after congenital syphilis; certain indurated masses and ulcers in the tongue, which have a tendency to ultimately become malignant; certain non-malignant tumours in the breast and testicle, having the structure of gummata; some strictures of the rectum; possibly some urethral strictures; indurations and enlargements of the bones of the limbs; adhesions of the soft palate to the walls of the pharynx; laryngeal stenosis from destruction of the cartilaginous framework, and necrosis of the bones of the nose. Some forms of fœtal bone-disease due to the transmission of syphilis through the mother from the father, without the mother necessarily showing evidence of the affection, are likewise regarded as post-syphilitic or para-syphilitic conditions, as are also rickets by Parrot and some other French authors.

Cure of syphilis.—It is now largely held that syphilis is essentially incurable. However long the apparent freedom, yet from some general or local impairment of health, a recurrence of the syphilitic disease may take place. Hence a periodic short anti-syphilitic course, *e.g.*, for three to six weeks every year, may be advised.

Congenital or inherited syphilis is syphilis transmitted to the offspring during intra-uterine life, and must be distinguished from syphilis acquired from a recently-infected mother during or after birth, or from a wet-nurse.

Infection.—The fœtus is believed to be generally infected through the spermatozoon of the father, which fertilises the ovum of the mother, *conceptional syphilis;* less often to be infected by the virus passing from the maternal to the fœtal circulation in the placenta, *placental syphilis.* As regards the latter method, smallpox, scarlet fever, pyogenic organisms, sometimes perhaps tubercle, and experimentally anthrax, are transmitted in this way. There is no sign of any maternal lesion, but many pregnancies end in abortion or stillbirth, the fœtus being overpowered by the toxins. When the child lives to term, it is usually born

looking healthy, and though the virus is present in the system, the disease does not manifest itself as a rule till the fourth to the sixth week. In rare instances, however, infants are born with well-marked signs of syphilis; on the other hand, at times the affection does not show itself till much later in life. But in the latter case the symptoms are those of the tertiary stage, not those of the secondary stage delayed. The *symptoms* in a typical case usually set in with a chronic catarrh of the nasal mucous membrane, popularly known as the *snuffles*, followed by a rash on certain parts of the body, especially the buttocks, and mucous tubercles and superficial ulcerations about the mouth and anus. The catarrh may simulate merely a cold in the head, or be attended with a muco-purulent discharge, and cause obstruction to respiration and difficulty in sucking. The eruption, like that of the secondary stages of acquired syphilis, is symmetrical, and of the same peculiar coppery or raw-ham colour. It is most common about the nates and genitals, where it is usually erythematous in character, and on the palms of the hands and soles of the feet, where it is commonly squamous. But it may be papular, and at times bullous or pustular. A well-marked mucous tubercle or condyloma about the anus is pathognomonic of the disease. These symptoms are frequently, though not invariably, accompanied by anæmia and wasting, the child looks shrivelled and old, the skin earthy and dry, whilst the hair may fall off, and the nails, iris, periosteum, and bones may be affected as in the acquired form. At this period death is far from uncommon. Usually, however, and especially under a mercurial course, the symptoms gradually subside, and by the end of the first year disappear altogether, and no further manifestation of the disease may occur throughout life. But frequently after several years of immunity, certain tertiary affections show themselves, the chief of these being interstitial keratitis, periostitis, and osteitis, followed by necrosis, disease of the ear often ending in total deafness, ulceration about the palate, chronic synovitis of one or more of the joints, and the formation of gummata in the viscera, testicle, etc. Along with these, certain important diagnostic symptoms, the result of the former secondary lesions, may be present, viz.: 1, a depressed and widened condition of the bridge of the nose, due to the influence of the nasal catarrh upon development of the nasal bones and septum; 2, radiating scars about the angle of the mouth, the result of the cicatrisation of the former ulcers (*Hutchinson's lines*); 3, a peculiar conformation of the skull, the result of the previous bone-lesion, consisting chiefly in a furrow above the eyebrows, a square forehead, and prominent frontal eminences; and 4, a characteristic appearance of the permanent central incisor teeth, consequent upon the action of the stomatitis upon them while yet soft and uncut. The distinctive sign of syphilis in these teeth is a slight crescentic notch in the biting edge (Fig. 22). They are also generally dwarfed, especially

in width, their angles are rounded off, and their sides convex in outline (*pegged teeth*). These appearances must be distinguished from those due to the action of mercurial stomatitis, the teeth so affected showing horizontal markings, or honeycomb-like excavations in the enamel (compare Figs. 22 and 23).

The bone-lesions of congenital syphilis were until recently overlooked, or confounded with those of rickets, which they much resemble. Two forms are described, the *osteophytic* and the *atrophic*. In the *osteophytic* the cranial bones present localised and symmetrical thickenings (*Parrot's nodes*) in the region of the frontal and parietal eminences (*the natiform or hot-cross-bun-like skull*) (Fig. 37), and the long bones subperiosteal enlargements. In the *atrophic* the cranial bones, especially in the occipital region, are thinned or locally absorbed, so that the brain is only covered at these spots by a thin membrane (*osteoporosis, craniotabes*), and the long bones are enlarged at their epiphyses by the production of ill-formed bone and the absorption of the normal bone. These lesions are usually transitory,

FIG. 22.—Syphilitic teeth. (After Hutchinson.)

FIG. 23.—Mercurial teeth. (After Hutchinson.)

and generally give rise to little inconvenience; but at times separation of the epiphysis may occur, with septic or tuberculous inflammation of the neighbouring joint; and when several bones are affected, the child may be so chary of movement on account of the pain it causes that infantile paralysis may be simulated. Healing is followed by ossification at the epiphyses, arrest of growth, and the production of deformities. Paralysis perhaps occurs although electrical reactions be retained, and it may now be viewed as a toxic paralysis, like that set up by diphtheria.

Treatment.—In the early stages mercury generally acts like a charm. It is best administered as an inunction by putting half a drachm of blue ointment on the binder of the child and allowing it to be thus rubbed into the skin. Or it may be given in the form of mercury and chalk in doses of from half to one grain, but is then apt to cause diarrhœa. Mercury, however, should be given with caution if there is much marasmus, and discontinued as soon as the symptoms have cleared up, lest mercurial stomatitis be induced and the permanent teeth suffer in consequence (Fig. 23). The child should be well and carefully fed during the mercurial course, and

small doses of cod-liver oil may often be taken with advantage. If the mother is unable to suckle the infant it must be brought up by hand, not by a wet-nurse, for fear of her nipple becoming affected with a primary chancre, a danger the mother herself does not run, even although she has exhibited no signs of syphilis.

In the later stages of congenital syphilis, as in those of the acquired form, iodide of potassium is indicated, and may frequently be advantageously combined with small doses of mercury, where the later lesions, as is too often the case, prove intractable Lastly, should syphilis be suspected in either of the parents during the period of gestation, mercury should be administered to the mother;

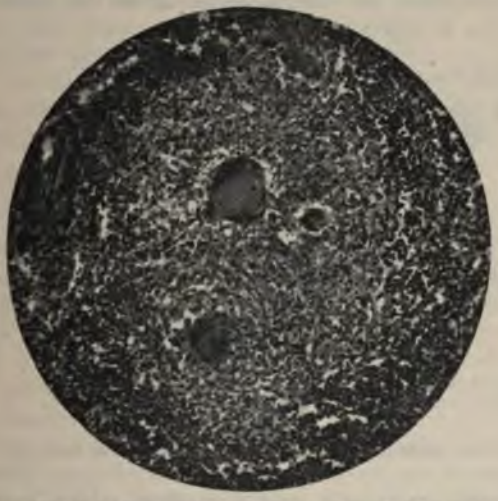

FIG. 24.—Photograph of a section through a tubercle. In the centre are one large and two smaller multinucleated giant-cells; the nuclei staining deeply are arranged round the periphery of the cell, which in the centre is undergoing caseous degeneration and losing its staining properties. Around the giant cells is a middle zone of endothelial (*epithelioid*) cells in a meshwork of fibrin, and external to this small round cells (leucocytes) are beginning to invade the middle zone.

and after the birth of a syphilitic infant the same treatment should be advised during any subsequent pregnancy.

TUBERCULOSIS AND THE INFECTIVE DISEASES ALLIED TO IT.

Tuberculosis is an inflammatory affection set up by the tubercle bacillus, and capable of inducing tuberculosis by transference to most animals. It is characterised by the production of tubercles, which may be limited to one set of tissues, or to an organ (*local tuberculosis*), or may be generally diffused throughout the whole body (*general tuberculosis*).

Structure of tubercle.—Tubercle is met with under two forms,

grey miliary nodules and yellow caseous masses. (*a*) The *grey miliary tubercles* have almost the lustre and hardness of cartilage. They are globular in shape and vary in size from a pin's point to a millet or mustard seed. They are sharply defined, and may be scattered throughout an organ or on a serous surface, or be grouped more or less closely. (*b*) The *yellow caseous masses* are soft in consistency and larger than the miliary tubercles, the larger masses being produced by the fusion of several tubercles, followed by degeneration. In some cases of general tuberculosis only the miliary form may be found, in other cases only the yellow variety; but frequently the two forms are mixed, and the various stages from grey to yellow, from the central softening of the miliary tubercle

FIG. 25.—Diagram of the minute structure of tubercle.

to its complete conversion into a caseous yellow mass, can be traced.

Microscopically a typical grey granulation when of some size is seen to consist of some smaller nodules aggregated together, whilst each of these again is composed of cells of various shapes and sizes, arranged in three zones (see Figs. 24 and 25). The inner zone is formed by one or more large branching so-called giant-cells, composed of a granular protoplasm, in which many large distinct oval nuclei containing nucleoli are found. The next zone consists of large single-nucleated cells, arranged between the branches or processes of the giant-cells, which ramify through the zone. These cells are called epithelioid, from their resemblance to epithelial cells, though they are now known to be of endothelial origin. The third or outermost zone consists of lymphoid cells, like ordinary uninuclear leucocytes, scattered through a delicate reticulum of branched connective-tissue cells, which is sometimes continuous with the processes of the giant-cells. There is no distinct line of demarcation between the outer zone of leucocytes and the surrounding tissues, but often a faint

indication of a fibrous ring may be detected. The tubercle-nodule, though often seated upon a small vessel, is itself completely non-vascular. The bacilli may be found in the giant-cells, especially in animals, and in and amongst the epithelioid cells. They are less readily discovered after caseation has commenced. They are rod-like bodies, usually straight, sometimes curved, rounded at the ends, and about one-fifth their length in breadth (see Fig. 26). Although the above may be regarded as the typical microscopical appearance of a miliary tubercle, often neither giant-cells nor epithelioid cells are present, while both these may be found in chronic inflammations which are not tuberculous.

Development of tubercle.—The tubercle bacilli having gained entrance to the body may remain at the point of entrance or be carried by the blood or lymph stream to other, perhaps distant, parts. A tubercle develops as follows:—(1) The bacilli being arrested in a capillary blood-vessel, a degeneration of the cells and ground-work of the tissue around begins.

Fig. 26.—The tubercle bacillus. (After Mcintyre.)

(2) Then an inflammatory exudation and emigration of leucocytes follows, whilst at the same time the remaining tissue cells proliferate to form fibroblasts rich in protoplasm, epithelioid in shape, the whole forming a nodular mass with bacilli in or between the cells. At the same time the remaining connective-tissue fibres have their strands widely separated, and these form the reticulum of the tubercle.

(3) One of the epithelioid cells at the centre enlarges in size, whilst its nucleus continues to divide until the daughter nuclei are arranged in a peripheral ring or horseshoe. The giant-cell is of late development, and is therefore to a certain extent a sign of chronicity. It is not a necessary part of a tuberculous nodule, and is met with in other forms of inflammation.

(4) Inflammatory small round cells or leucocytes arising in the inflammation around invade and in large measure obscure the epithelioid cells, until the tubercle has the appearance of a small-celled nodule infiltrated with fibrin.

Degeneration of tubercle.—(1) Caseous degeneration is partly the result of toxins derived from the bacilli, partly perhaps due to the cutting off the blood supply from the centre of the tubercle by the leucocytes. It commences in the centre of the giant-cell, which ceases to stain with logwood, whilst the nuclei, and especially the leucocytes, still stain deeply. The process spreads centrifugally to convert all the tubercle into a cheesy mass. (2) In chronic tuberculosis, instead of caseation occurring, a capsule of fibrous tissue may

be formed around the nodule, and the cicatrisation extending inwards until the giant-cell is involved, the whole tubercle may be converted into a mass of fibrous tissue. The tubercle bacillus is not found under such conditions. (3) After caseation has occurred the tubercle may become encysted, or may undergo calcification, in both of which states it may remain harmless; or (4) it may become infected with pyogenic micrococci, which, acting as irritants, set up inflammation and suppuration in the tissues around, leading to the formation of an abscess, and subsequently, on its bursting, to an ulcer. The formation of a chronic abscess may, however, be due to the sole action of the tubercle bacillus without the intervention of other pyogenic organisms.

Infection.—The bacillus is believed in man to gain admission (1) by the *digestive tract*, as in the saliva of a phthisical mother or nurse, in milk taken from cows with tuberculous udders, or in imperfectly-cooked tuberculous meat; (2) by the *respiratory tract*, as by the inhalation of the dust of dried phthisical sputa, etc. (*aërogenous tuberculosis*); and (3) by the *skin*. It is still doubtful if man is often inoculated through the skin. In a few cases inoculation has followed circumcision in Jews, through the saliva of a phthisical operator. In anatomical warts which have a tuberculous structure, there seems little tendency for tubercle to spread beyond the point of inoculation.

Inheritance of tubercle.—The direct inheritance of tubercle is usually emphatically denied, perhaps unduly so. The children of some phthisical parents do develop tubercle in infancy with severity, and during growth and in adults a tuberculous lesion appears very frequently amongst descendants of those who have suffered from that disease. It may be explained that whereas the tubercle bacillus is really transmitted from parent to offspring *in utero*, that it remains latent for a long period in most cases. The bacilli have been found in the fœtal membranes and liver, the mother exhibiting miliary tuberculosis. The infection of the fœtus has been accomplished experimentally in animals.

Predisposing causes.—The children of phthisical parents appear to be specially susceptible to tuberculosis. Impairment of nutrition induced by bad hygiene and food; by imperfect assimilation of food; and by the prolonged action of other infective agents, pyogenic organisms, syphilis, etc., no doubt predispose to the attack of the bacillus. The evil influence of want of exercise and of fresh air, also the unsuitable character of damp and cold climates, is strikingly shown in the case of wild animals, particularly monkeys, in confinement, who become specially liable to tuberculosis, although well fed and cared for. The debilitated state of the system predisposing to the affection was formerly spoken of as the *strumous* or *scrofulous diathesis*, but as it is now known that the inflammatory affections formerly called strumous or scrofulous are really tuberculous,

the constitutional condition that favours the attack of the tubercle bacillus had better be termed the *tuberculous diathesis*. The signs of this so-called diathesis are thus given by the late Sir William Savory, who speaks of two chief forms:—"In the first variety, distinguished as the *sanguineous* or *serous*, there is a general want of muscular development; for although the figure may be sometimes plump and full, the limbs are soft and flabby; the skin is fair and thin, showing the blue veins beneath it; the features are very delicate; often a brilliantly transparent rosy colour of the cheeks contrasts strongly and strikingly with the surrounding pallor; the eyes, grey or blue, are large and humid, with sluggish pupils sheltered by long silken lashes; hair fine, blonde, auburn, or red; teeth white and often brittle; there is frequently a fulness of the upper lip and alæ nasi; the ends of the fingers are commonly broad, with convex nails bent over their extremities. Such persons usually possess much energy and sensibility, with elasticity and buoyancy of spirits; they often possess, too, considerable beauty. In this variety, with the same delicacy, the skin and eyes are sometimes dark. In the second, distinguished as the *phlegmatic* or *melancholic*, the skin, pale or dark, is thick, muddy, and often harsh, the general aspect dull and heavy; hair dark and coarse; the mind is often, but not always, slow and sluggish. Children especially, in whom the diathesis is strongly marked, are often distinguished by the narrow and prominent chest, the tumid and prominent abdomen, and the paste-like complexion; the limbs are wasted; the circulation languid; chilblains are common on the extremities; the mucous membranes particularly, and above all of them the digestive, are liable to morbid action; the breath is often sour and fœtid; the tongue is furred, and the papillæ towards the apex red and prominent; the bowels act irregularly, and the evacuations are unusually offensive; the digestion weak; the appetite variable and capricious." Tubercle is most common in the young, but adults and even old people are liable to it when exposed to like unfavourable conditions, a slight inflammation or injury then generally forming the starting point.

Dissemination of tubercle.—The bacillus having gained admission in one or other of the above-mentioned ways is believed to set up the tuberculous process as previously described. The tuberculous process may then (1) remain confined to the seat of inoculation, as in some forms of tubercle of the skin (*lupus and post-mortem warts*). Or (2) with or without any local manifestation it may spread by the lymphatics to the nearest lymphatic glands and there become arrested. As an example of this may be mentioned the tuberculous enlargement of the glands of the neck, in which the bacillus is believed to gain admission through a crack or small ulcer of the mucous membrane of the mouth or through an inflamed tonsil. Again, (3) the bacillus may pass the glands and enter the

lymphatic or hæmic circulation, and then either (*a*) become lodged in some organ or distinct part of the body, as the testicle, a bone or a joint, or (*b*) become disseminated, setting up general acute tuberculosis (*lymphogenous and hæmatogenous tuberculosis*). The brunt of the affection falls in the latter case either on the lungs (*acute miliary tuberculosis of the lungs*) or on the membranes of the brain (*acute tuberculous meningitis*). When affecting an organ or tissue, as a testicle or a joint, it may remain localised for a longer or shorter time, and even become cured; or it may set up inflammation, and involve and destroy the whole organ; or finally become generally disseminated through the system, leading to general tuberculosis.

Localisation of tubercle.—Tubercle has a special affinity for certain organs and tissues to the exclusion of others. Serous membranes, such as the pleura, peritoneum, pia mater, and arachnoid, are especially liable to be affected; whilst, on the other hand, the pericardium and the tunica vaginalis show an immunity. Of all organs the lung is most prone to suffer; next, though much less frequently, the testicle, kidney, brain, liver, spleen, suprarenals, and ovaries. The larynx and intestines may become involved by the bacillus coming into contact with them either in the breath or in swallowed sputa; yet the trachea, the stomach, and the upper part of the intestine generally escape. The bones and joints are frequent seats of the disease, which has a special predilection for the cancellous ends of the long bones and for the short bones. The upper end of the femur and hip-joint, the ends of the femur and tibia forming the knee-joint, and the short bones and joints of the foot and hand are most often affected, the elbow-joint less often, and the upper end of the humerus and the clavicular joints but rarely. The scapula and ilium with the acetabulum may suffer, but the shafts of the long bones, the clavicle, and the ischium and pubes, apart from the acetabulum, escape. The bodies of the vertebræ are frequently attacked, while the laminæ, with the spinous and transverse processes, remain free. The bones of the skull are sometimes involved, those of the jaws and face never. Tuberculosis may occur in the skin and affect the glands, but lupus, which is a form of tuberculous disease, does not spread to the glands. The reason for tubercle affecting any special organ or tissue is not known, but it is thought to depend on some previous lowering of vitality of the part, as a sprain of a joint, a blow on the testicle, etc.

A general though brief account of tubercle has been here given to prevent repetition when treating of tuberculous diseases of certain organs. As a surgical affection, it is chiefly met with in the bones, joints, testicle, lymphatic glands, skin, larynx, and more rarely in the bladder and rectum. All that need here be said is, that such lesions are of a very chronic and indolent nature; that they are set up by very slight and apparently inadequate causes; that they

exhibit a marked tendency to suppuration and progressive destruction or undermining of the tissues, and but little tendency to repair; that they are often productive of much scarring and deformity, as when they occur as abscesses in the neck; that they are generally very obstinate and intractable as regards treatment; and that they may terminate in general dissemination of the tubercle through the body, and death.

The *treatment* should be both constitutional and local. Thus the patient should be placed under as perfect hygienic conditions as possible, with residence at the seaside, preferably Cromer or Margate, or where practicable he may go a sea-voyage. Of late great benefit has been obtained by what is called the open-air treatment, combined with "feeding-up." The diet should be nourishing, but unstimulating, with plenty of milk and cream, whilst cod-liver oil or maltine and the syrup of the iodide or phosphate of iron are especially indicated. Koch's tuberculin is a material in solution obtained from dead tubercle bacilli, which causes local inflammation in any part affected by tubercle with some general fever. It has rarely had a beneficial influence; in some cases it has even had an injurious effect upon the course of the disease The local treatment required for the various lesions that may be present is given when describing these lesions as they occur in special tissues and organs.

Leprosy.—*Leprosy* is a disease set up by the bacillus lepræ, which gives rise to nodules, composed of cells of various sizes lying in a fibrous ground-work. It occurs in Scandinavia, East Russia, the shores of the Mediterranean, in Mexico and adjacent portions of South America, the Cape, and is very prevalent in the Pacific Islands and in India and China.

The bacilli lie between the cells or in cells which tend to become much swollen with numerous nuclei. Later, these multinucleated giant-cells become mere vacuoles filled with bacilli. According to some, this latter appearance is due to lymph spaces crowded with bacilli. The bacilli closely resemble in appearance and staining properties the tubercle bacillus, but have not been artificially cultivated, and animals appear to be immune to the disease. The secretions from the nose, the sputa, and discharge from ulcers are believed to be the means of transferring infection, especially by infecting the nasal mucous membrane. As favouring this occurrence is the herding together, and perhaps also sexual connection, of lepers. According to Mr. Jonathan Hutchinson an excessive diet of salt fish may be regarded as predisposing to the disease.

The parts chiefly affected are the skin, the nerves, the nose, and pharynx; also other organs, such as the testis, liver, spleen, lymphatic glands. The penis is frequently affected in Cuba. The disease consists in the formation of nodules, tuberous masses, and indurations, which may exist for years or shrink to scar tissue with disturbances of pigmentations, but which do not, as in tubercle, caseate. But, owing

to external influences, ulceration and erysipelatous complications may arise, and the ulcers show little or no tendency to heal. Meanwhile, the submaxillary and inguinal lymphatic glands form indurated swellings. The leprosy of the skin may appear as red patches, going on even to vesication and a tendency to connective-tissue proliferation around, attacking especially the extensor surfaces of the knee and elbow, and the dorsal surfaces of the hands and feet. The nodules may remain stationary or enlarge to tuberous masses on the face (*facies leontina*), ulcers easily form, and have little tendency to heal. New nodules continue to appear, also erysipelatous-like redness and swelling is apt to arise. Leprosy nodules in the nerves produce, first, hyperæsthesia and pain ; later, anæsthesia, more rarely loss of motor power. White and brown patches, *lepra maculosa, morphœa nigra et alba*, appear, produced by pigmentation and atrophy, with wasting of bones and muscles. In the anæsthetic stage injuries pass unperceived, producing ulceration and necrosis with loss of phalanges. Besides the skin and nerves, other viscera may suffer.

Actinomycosis is an infective disease depending upon the presence in the tissues of a polymorphic bacterium, the actinomyces or ray-fungus (*streptothrix actinomycotica*).

Cause.—The disease, which is prevalent in cattle, is probably set up in them by the fungus which exists in the cells of grass and corn taken as food. It also appears in man to be generally conveyed by cereals. A grain of wheat or barley has been found in several growths. It may in rare cases be transmitted to man from the diseased animal, as has been said to occur in cowmen. A common site of inoculation is through a carious tooth, but the parasite may gain admission by the alimentary and respiratory tracts or through a cutaneous wound.

Pathology.—The actinomyces, having entered the tissues, sets up a progressive inflammation leading to the formation of granulation tissue, tough fibrous tissue and pus. The pus contains pale yellow, or sometimes white or brown grains, which are visible to the naked eye when the pus is spread out in a thin layer, the larger grains being about the size of a pin's head. These grains are seen, on careful microscopical examination, to be made up of fine threads of mycelium, with sometimes club-shaped ends. The "clubs" are often absent and are believed to be involution forms and not essential to the disease (Fig. 27).

In cattle the disease affects chiefly the lower jaw, but it has also been met with in the upper jaw, the tongue, the respiratory and alimentary tracts, and in the subcutaneous and intermuscular tissues. It was formerly included under the names of osteo-sarcoma, wooden tongue, bone-cancer, tubercle, etc.

The organisms form long jointed threads matted together into a dense ball, forming a grain visible to the naked eye, which, when compressed under a cover-glass takes a radiate appearance, but when

examined in sections stained by Gram's method show the mycelial-like threads to be cut in various directions. Under some circumstances, the threads break up into very short rods, almost cocci, which can again grow into threads. The ends of the threads may degenerate by swelling of their limiting membrane, which produces the appearance called "clubs," but the clubs are not at all a frequent appearance in man. It is the ball of threads staining by Gram's method, surrounded by inflammatory tissue or floating in the pus, by which the disease is recognised. The organism is

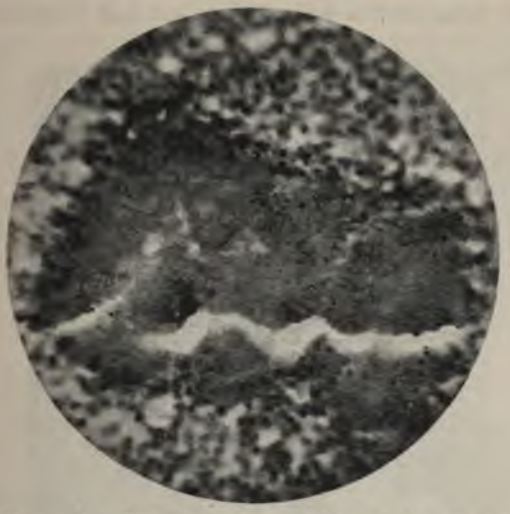

FIG. 27.—Actinomycosis. Photograph of a granule stained by Gram's method. It is a ball of mycelial threads. The threads in focus are shown in the photograph. The rest of the granule, as well as the inflammatory cells around, appear blurred from having been out of focus. The photograph partly shows what can be much better seen through a microscope when the fine adjustment is moved. This is the characteristic appearance, and not the "clubs," as formerly drawn in diagrams.

cultivated with difficulty, and inoculation experiments, best made in calves, are uncertain.

In man actinomycosis may appear (1) in the skin, especially that of the face, neck (Fig. 28), breast, or abdominal wall; (2) in the mucous membrane of the mouth, pharynx, œsophagus, intestinal tract, appendix, or bladder; or (3) in the viscera, as the liver or lung, and in a few rare cases the brain.

Symptoms.—When it occurs in the *mouth* it is commonly met with about the socket of a carious tooth, and infiltrates, as a rule, the lower jaw. A great deal of thickening occurs in the surrounding bone, and abscesses are formed in the neighbouring connective tissue. Sooner or later a tumour generally forms about the angle of the jaw, and involves the skin of the face and neck.

After opening of the abscesses sinuses are left leading into the swelling, which is found to consist in part of tough fibrous tissue and in part of soft vascular granulation tissue filling cavities in the bone. The escaping pus contains the grain-like masses of the fungus which are characteristic of the disease. When actinomycosis invades the *cutaneous surface* the appearances are that of a brawny, purplish-red, irregular swelling, which in places soon softens into abscesses, and these, on bursting, leave sinuses discharging characteristic pus, and then cicatrise, whilst other abscesses form around. Thus the mass acquires an irregular consistency, being riddled with sinuses, soft and fluctuant in places

Fig. 28.—Actinomycosis of the face. (From a drawing of a patient St. Bartholomew's Hospital Museum.)

where abscesses are forming, puckered, firm, and indurated where cicatrisation has taken place. When the disease occurs in *bones* other than the jaw, it gives rise to a growth with characters similar to those mentioned above. When it begins in the *lung* it may spread to the pleura and then extend widely in the chest-walls and to the spine. From the *intestine* it may invade the peritoneum and abdominal walls. The portion of intestine most often affected is the cæcum. The disease may then give rise to symptoms resembling appendicitis, namely, a feverish attack with constipation and perhaps vomiting, attended by a swelling in the right iliac fossa. The peculiar induration, and after an incision has been made, the escape of pus containing the fungus, will settle the diagnosis. In whatever situation it begins, if left alone, it steadily spreads until it kills either by exhaustion or by involving some vital organ. Infection does

not appear to occur in the lymphatic glands communicating with a primary focus of actinomycosis, but metastases arise in the liver, and a pyæmic form of actinomycosis is occasionally met with.

Diagnosis.—The disease perhaps most resembles a breaking-down syphilitic gumma, tuberculous ulceration, or a fibro- or myxo-sarcoma attended by profuse suppuration. The presence of the parasite in the pus will clear up any doubt as to the nature of the disease.

Treatment.—The most efficient treatment is the complete removal

Fig. 29.—Mycetoma. Madura disease affecting the bones of the foot. (Copied, by kind permission, from the paper by Lieut.-Col. Keith Hatch, in the *Medical Annual*, 1900.) Photograph of a specimen in the Grant Medical College Museum. The bones appear to have undergone caries, but show also the peculiar round holes and channels made by the granules.

of the growth, whilst it is still local, by excision and scraping. In the lower jaw this has been attended with complete success. When the disease is too extensive to admit of removal, free drainage and injections of carbolic acid, 1 in 20, into the sinuses should be used, and large doses, 40 to 60 grs., or more, of iodide of potassium given internally. This drug has been found of great value, both in man and in cattle, and should always be given, whether local treatment is or is not undertaken.

Madura disease or Mycetoma, the fungus disease of India.—*Madura* is a disease caused by a variety of streptothrix, (*Streptothrix maduræ*), which is inoculated most commonly into the feet of the natives of India engaged in agriculture, who habitually go

barefoot, and who are therefore liable to injury from thorns, etc. It is usually the ball of one foot, not both, less often the hand or leg, which is infected, and the toes and foot slowly swell to a misshapen mass, composed of fibrous and fatty tissue, whilst the bones become destroyed in a manner very like tuberculous caries. The grains of the streptothrix have been compared to seeds, to roe, to grains of gunpowder. Sometimes the granules are black, sometimes white or whitish-yellow. Sinuses discharging pus form, the limb above

Fig. 30.—Mycetoma. The black variety affecting the hand, showing the sinuses. (From the same source as Fig. 29.)

atrophies, and the patient becomes exhausted. An extension by the lymphatics to glands has been noted in late cases. The diagnosis from tuberculous disease is made by finding the granules. *Treatment.*—Amputation. Iodide of potassium and carbolic-acid injections with scraping do not benefit.

Glanders is a specific infective disease common amongst horses, and occasionally communicated to man by inoculation through a wound of the skin or the unbroken mucous membrane with a specific form of micro-organism, the *Bacillus mallei*. This bacillus after several cultivations retains the power of reproducing the

disease in the horse. The disease may run an acute or chronic course. It is nearly always acute in man and chronic in the horse. *The acute form* is characterised: (1) by a thin serous discharge, rapidly becoming foul, purulent, and sanious, from the nasal mucous membrane, with enlargement of the submaxillary glands; (2) by a pustular eruption, resembling that of smallpox, on the skin and mucous membrane of the respiratory and digestive tract; and (3) by the formation of circumscribed nodules in the lymphatics of the subcutaneous and muscular tissue, which usually soon break down into abscesses and foul ulcers. These signs are ushered in and accompanied by fever, which rapidly assumes a typhoid type and is sometimes preceded by a rigor. Symptoms of pneumonia or pleurisy, or vomiting and diarrhœa ensue, according as the respiratory or alimentary tract is chiefly affected, and death usually takes place within a week or ten days from septicæmia or pyæmia. In the *chronic* form the constitutional symptoms are less severe, and the patient may linger for months, or even recover. Nodules like gummata then form in the skin, muscles, and bones, and break down.

In the horse the disease is spoken of by veterinary surgeons as *farcy* when the lymphatic vessels and glands are principally affected, the swellings opposite the valves in the lymphatics forming the so-called "*farcy-buds*"; and as *glanders*, when the disease falls chiefly upon the nasal mucous membrane. In man the two processes generally occur together as above described.

Diagnosis.—The fact that the patient's occupation brings him into contact with horses or that he has been in attendance on an animal known to be glandered should excite suspicion. The detection of the bacillus mallei in the discharges on bacteriological examination will serve to distinguish the *acute* disease from small-pox, acute rheumatism, septicæmia, and pyæmia, and the *chronic* form from syphilis and tuberculosis, for all of which glanders may be mistaken.

A chemical substance (*mallein*) present in the artificial cultures of the glanders bacilli produces no reaction when injected into the tissues of healthy animals; but when injected into the tissues of animals affected with glanders a decided rise of temperature takes place. A means of making an early diagnosis in the horse is thus afforded, and by its use the disease can be stamped out of infected stables.

Treatment.—Beyond supporting the patient's strength with concentrated fluid nourishment, scraping and curretting the infected surfaces, opening abscesses as they occur, dressing the ulcers antiseptically, and syringing out the nasal chambers with antiseptic lotions, little or nothing can be done, as no treatment appears to have been hitherto of any avail in the acute form. Seeing how highly infectious is the disease, however, the patient should be isolated, and the strictest antiseptic precautions taken to prevent the spread of the disease to the attendants.

Infective Diseases Especially Influencing the Nervous Centres.

Hydrophobia is a specific infective disease, always propagated by inoculation, and probably due to a specific micro-organism. It has received its name from the prominent symptoms which the pharyngeal spasms produce. It is called rabies in dogs because no fear of water is shown, and because in them there may be great excitement. The disease is generally received by man from the dog, occasionally from the wolf, and more rarely from the cat or fox, and by these animals it may be given to horses, deer, etc. The inoculation is generally through a bite by which the saliva containing the virus reaches the lymphatics. At times it has occurred through a scratch which has been only licked by the affected animal, and once through making a post-mortem examination on a subject who had died of the disease. Of all persons bitten by rabid animals, about 15 per cent. only suffer from the disease, a fact which probably in chief part depends upon the saliva being wiped off the teeth as they pass through the clothes. The most dangerous wounds are those on the face and hands, and on the bare legs of children, the average mortality of bites on the face being as high as 60 to 80 per cent. Multiple and lacerated wounds are naturally most to be feared, as inoculation in them is more likely to take place. Also the nearer the bite is to the central nervous system, the more easily and rapidly does the poison reach the brain and begin to take effect. Indeed the only certain method of producing the disease in animals is by inoculation under the dura mater. It was the discovery of this fact which led M. Pasteur to make his investigations.

The *average period of incubation* varies from two weeks to six months. Although it is said that the incubation period has been as short as two days, and as long as twenty years, two weeks to two years may practically be given as its limits. There are no symptoms during this period. The vesicles or lyssæ said to occur under the tongue from the third to the ninth day after the bite do not appear to be a constant phenomenon. The virus has no influence on the healing of the wound, the bite of a mad dog healing like other wounds, either by first intention, or, if the tissues are badly lacerated, slowly and painfully.

Seeing therefore that there are no symptoms during the incubation period, and that in the early stages of rabies there are no naked eye post-mortem signs, the only way of ascertaining if the bite is that of a mad dog is to watch the animal. If the dog is killed at once the patient will suffer much mental anxiety. He must wait for three weeks before the point can be determined by inoculation experiments on rabbits, or he may undergo Pasteur's treatment unnecessarily. Moreover, to wait three weeks may be too late for wounds of the face. Every suspected dog, therefore, should be confined in a strong cage. If mad he will show advanced

symptoms, and die in three or four days. It is important, therefore, to recognise the symptoms of rabies in the dog.

Symptoms of rabies.—The earliest symptoms are restlessness, dulness, and a tendency to shun the light. The dog often roves far and wide, and has a morbid appetite for pieces of stick, hay, stones, etc. In the next stage he may rush wildly about, biting other dogs, inanimate objects, or men, frequently those to whom he has been previously attached. The appetite is lost, there is a desire to drink, and the muzzle is put into the water, but none is taken. Finally he becomes paralysed, the lower jaw begins to drop, the bark changes to a characteristic hoarse howl from pharyngeal paralysis, next the limbs fail, and finally the muscles of respiration. Sometimes, however, advancing paralysis is the only symptom, the power of barking being then lost. This form of the disease is called *dumb rabies.*

Post-mortem signs of rabies.—The stomach contains hay, sticks, stones, etc., and its mucous membrane is congested and scattered over with small hæmorrhages. The trachea is congested and may also be dotted over with small hæmorrhages. The nervous system, especially the cord and medulla, show signs of acute myelitis. This begins with an exudation of leucocytes into the sheaths of dilated vessels, then hæmorrhage, and finally softening. If a portion of the medulla or cord is required for inoculating purposes, a piece should be placed at once in a 20 per cent. solution of glycerine and kept there for three or four days to kill septic micro-organisms ; an emulsion is then made and a drop or two injected under the dura mater of a rabbit, which will die in from eighteen to twenty-one days, showing first excitement and then paralysis of the hinder limbs, extending later to the fore-limbs and head.

Pathology of hydrophobia.—The principal post-mortem changes in man have been found in the medulla, especially about the region of the glossopharyngeal, pneumogastric, and hypoglossal nuclei, and in the cerebral cortex. They consist in the infiltration of the peri-vascular sheaths with leucocytes, thrombosis of the medium-sized vessels, small hæmorrhages, and degeneration of the nerve cells ; in short, as in animals, of an acute myelitis. The theory now generally held with regard to the pathology of the disease is that the poison after remaining for a variable time dormant in the wound, multiplies or matures ; and then that either it or its products slowly enter the blood and set up a specific inflammation in the medulla and cerebral cortex, whereby their power of resistance to reflex-irritation is diminished or lost. Hence the occurrence of the spasms on the slightest provocation. Finally, that should the patient not succumb to spasm of the glottis or muscles of respiration, the affected nerve-centres become exhausted and no longer respond at all to the reflexes necessary to carry on life, and the heart's action in consequence ceases. The nature of the poison is not known,

though the belief is gaining ground that the disease depends in some way upon a micro-organism, since rod-like bodies have been discovered in connection with the hæmorrhagic lesions in the cerebral cortex, and a micro-organism has been isolated by inoculating fowls with the virus taken from rabid animals.

Symptoms of hydrophobia.—At first there may be pricking pain, perhaps some redness and tumidity, at the site of the wound, which has generally long since healed. The patient, if an adult, has often much mental anxiety, and with the onset of the symptoms may become melancholic. As the disease becomes fully developed the symptoms point to disturbance in the medulla, especially about the centres for deglutition and respiration. Thus there is increasing difficulty in swallowing in consequence of pharyngeal spasm, and a peculiar click in respiration in consequence of spasm of the diaphragm. The pharyngeal spasms are at first only excited by attempts to swallow, but subsequently the sight of water and the sound of its trickling from one vessel to another, a blast of cold air, or a sudden light is sufficient to set them up. Swallowing is now quite impossible, and viscid saliva is forcibly hawked up and expectorated about. The spasms, which begin in the pharynx, extend to the muscles of respiration, and then become general; the pain is agonising, and the patient may have hallucinations or violent delirium, but often remains sensible of his dreadful condition to the end. Paralysis finally ensues, and death usually occurs from involvement of the respiratory muscles. The spasms sometimes diminish as the paralysis advances, and the patient may sink into a delusive calm, during which the power of swallowing may be regained. Sometimes the chief symptom throughout is advancing paralysis. Such cases resemble dumb rabies of dogs.

Death may be due in the earlier stages to spasm of the glottis or muscles of respiration; later to paralysis of the muscles of respiration or to exhaustion.

Diagnosis.—The *intermittent* character of the spasms (*clonic spasms*), the hallucinations, and the escape of viscid saliva from the mouth, will generally serve to distinguish hydrophobia from tetanus following the bite of a dog, and from false or hysterical hydrophobia. In the latter case, too, the convulsions will cease if the patient is put under chloroform.

The prognosis when the disease is once developed is hopeless. There is no authentic case of recovery from hydrophobia.

Prevention.—Hydrophobia can be and has been practically stamped out by muzzling dogs or by quarantining them at the port of entry. In countries where wolves abound the disease cannot be got rid of until the wolves are killed. But it has been abundantly proved that the disease is really spread by these two animals, and in others dies out.

The treatment may be divided into the preventive and palliative.

Preventive treatment.—If the patient is seen immediately after the

bite, we should endeavour to remove the poison from the wound, or else destroy it. This may be attempted by suction, a procedure which appears to be quite safe provided there is no crack or abrasion about the lips or tongue; or if at hand, a cupping-glass may be applied. The parts should afterwards be excised or thoroughly cauterised, the best caustics being nitric acid, nitrate of silver, caustic potash, and pure carbolic acid. It has been advised that if the wound has already healed when the patient is seen the cicatrix should be cut out; but it is more than questionable if this procedure is of any value, especially as it appears that if inoculation by M. Pasteur's method is resorted to before symptoms come on, the disease may be effectually prevented from developing.

Pasteur's treatment.—This consists in obtaining a virus of fixed strength and then attenuating it so that it can be safely inoculated. To obtain the fixed virus the disease is transmitted through a series of rabbits, the period of incubation becoming less and less as the virus increases in intensity, till, after passing through upwards of eighty rabbits, the period of inoculation is found to be constant and the virus of maximum intensity. A rabbit inoculated with this fixed virus always develops symptoms on the seventh day and dies on the tenth. To attenuate the virus a portion of spinal cord of a rabbit inoculated with the fixed virus is suspended in a sterilised bottle over caustic potash. As the cord dries the virus becomes less virulent, so that after two days' drying a rabbit inoculated with it dies in from 11 to 17 days; after 7 days' drying from 23 to 29 days; after 11 days' drying from 30 to 35 days; until after 12, 13, or 14 days' drying its virulence is completely lost. An emulsion is made of 0·5 centigrams of spinal cord in 2 cubic centimetres of sterilised beef-tea, and a drop or two is subcutaneously injected under the skin of the abdomen or flank. The cords are used in an ascending series from the fourteenth or fifteenth day of drying upwards, until on the ninth day of treatment a cord which has been dried for only three days is used. The treatment is continued for sixteen days. The above is known as the *Simple method.* For face-bites a more rapid method has been found necessary to prevent the disease. In this, which is called the *Intensive method*, a cord of only three days' drying is used on the sixth day, and the treatment is continued with two days' intermission until the twentieth day. This method, however, appears to be somewhat dangerous, a few patients so treated having died with symptoms of the paralytic form of the disease similar to that induced in animals by inoculation. The average mortality between 1886 and 1899 was 4 in 1,000 among those treated at the Pasteur Institute as compared with a natural mortality of 150 in 1,000.

Palliative treatment.—When hydrophobia has supervened, all that can be done is to relieve symptoms. Thus the patient should be placed in a darkened room, and every source of irritation that may

cause spasm avoided. Opium and morphia should also be given for the same purpose. Chloral, chloroform, eserine, pilocarpine, curare, and many other drugs have been given; but all are useless, and some, as chloroform and curare, are not unattended with danger.

Tetanus is a disease in which the voluntary muscles are thrown from time to time into a state of intense spasm, whilst they remain in the intervals in a condition of constant contraction (*tonic spasm*).

Cause.—Tetanus was formerly attributed to a lesion of the peripheral nerves; but is now known to be a toxic infection, depending upon a specific virus generated by the growth of the tetanus bacillus. It is especially prevalent in hot climates, and amongst the negro races; it occurs more often in men than in women, and in military than in civil practice. It is especially common after lacerated and punctured wounds and burns; but it has been met with after every kind of wound, from a mere scratch, or the ligature of a pile or the umbilical cord, to amputation of the thigh or other capital operation. Tetanus, however, has been more often observed when the wound, whatever its cause and character, is in a septic condition. Exposure to cold, damp, and sudden changes of temperature were believed to influence its production, and where tetanus occurs, as it sometimes does, without an apparent wound, were regarded by some as the essential cause. It would appear, however, that such conditions merely act as depressing agents, and that the micro-organism in these cases gains admission through a scratch or abrasion which has been overlooked.

Tetanus is inoculable from animal to animal, and probably from animals to man, since a veterinary surgeon has died of tetanus after making a post-mortem examination of a horse dead of the disease. It has been caused by catgut ligatures doubtless derived from infected sheep, and it has followed vaccination, diphtherial-antitoxin injections, and the gelatin treatment of aneurysm, probably from the serum and gelatin having been taken from horses suffering from chronic tetanus.

Pathology.—At times the nerves leading from the wound have been found congested, at other times unaltered in appearance. Hyperæmia of the medulla and cord, exudation in and degeneration of the grey matter, and hæmorrhages in the white columns, have been noted in some cases; whilst in others nothing abnormal in the nerve-centres has been discovered. The *modern view* of the pathology of tetanus is that it is a toxic infection due to a specific virus which affects the medulla and cord in a way similar to strychnine. The virus (*tetanin, tetano-toxin*) is a chemical compound, but according to the researches of Vaillard, Vincent, Brieger and others, is neither an alkaloid nor an albumose, but is allied to snake-poison or an enzyme. It is generated in a wound by the growth of the tetanus bacillus. It is only within recent years that an absolutely pure culture of the bacillus has been obtained by Kitasato, but since then its cultivation has become easy (Fig. 31). The bacillus occurs as

long delicate threads with slightly rounded ends. When sporing, these threads break up into short rods which usually develop a spore at one end, giving them a drumstick shape. It is anærobic, and hence rapidly loses its virulence on exposure to air. Its special habitat would appear to be ordinary earth, thus serving to explain the frequency of tetanus in the wounded who have been allowed to lie on the ground after battles. It has been found in the surroundings of horses, the floor of stables, and in soil taken from beneath the floor of hospital wards in which cases of tetanus have occurred. The bacillus only exists in the soil or in the wound; not in the blood or nervous system. The bacilli proliferate or grow only at and around the site of inoculation, and do not spread into the blood or invade the organs; again, they do not survive long in the wound, for a few days after infection they cannot be discovered either microscopically or by artificial cultivation. The bacilli manufacture a toxin, which is absorbed, and passing along the perineural lymphatics reaches the spinal cord, and acting on the motor cells produces the characteristic spasms. Cutting out the nerves of a limb of an animal which has been inoculated in that limb, delays the onset of tetanus considerably, and thus a former method of treatment, the excision of nerves, finds some pathological support. Experimentally all the symptoms of tetanus can be produced by injections of the germ-free toxins of tetanus cultures. The toxin does not cause spasms immediately after inoculation, and with small doses it may require days before any appear. In experimental animals the spasms become apparent first in the muscles nearest the seat of inoculation. It is curious that animals may be carefully inoculated with large doses of toxin-free spores or bacilli without contracting tetanus, while a few such spores or bacilli inoculated together with other organisms, such as the *Bacillus coli communis* or the pyogenic cocci, will readily produce it. Clinically, also, tetanus complicated by septic or suppurating wounds is severer than tetanus associated with a slight or clean wound. The tetanus toxin can frequently be found by inoculation experiments in the blood both during life and after death, and is not eliminated to any appreciable degree by the urine.

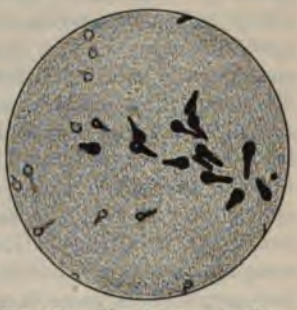

Fig. 31.—The tetanus bacillus. × 1,000. (After Sternberg.)

The *symptoms* usually begin by a feeling of stiffness in the muscles of the neck; the patient complains that he is unable to open his mouth widely (*trismus*), and that his throat feels sore on swallowing. On examination, the muscles of the neck, the masseters, and perhaps the abdominal muscles, are found hard and rigid, and the face

presents a characteristic expression from the angles of the mouth being drawn slightly upwards by the contraction of the facial muscles. Later, other of the voluntary muscles, especially those of respiration, become affected, and distinct spasms, attended with severe pain and varying in duration, occur from time to time. The spasms are induced by the slightest irritation, a breath of air, the least noise, the merest touch, and the remissions become shorter, or only partial, as the disease is fully established. During the spasms the face assumes an expression of intense anguish (*risus sardonicus*), the respirations and pulse are quickened, and the body is variously contorted. Thus, when the spinal muscles are chiefly affected the back becomes arched, so that in severe cases the patient rests only on his head and heels (*opisthotonos*); more rarely the body is bent forward, being rolled up as it were like a ball (*emprosthotonos*); whilst still more rarely it may be drawn to one or other side (*pleurosthotonos*). The skin is bathed in perspiration, the urine concentrated and high-coloured, and the bowels obstinately confined. The temperature may remain normal, or be but slightly raised; though sometimes shortly before death it runs very high, and has been known to register 112° F. The patient is unable to sleep, but the intellect continues clear to the end. Death may occur from spasm of the glottis, spasm of the respiratory muscles, or from exhaustion or syncope. Recovery hardly ever takes place when the symptoms are acute, but if the patient survive till the twelfth day the prognosis is more favourable, and becomes more and more so every day.

Varieties.—Clinically several forms of tetanus may be recognised. In *traumatic* tetanus a wound is always found, which may be no more than a mere scratch or puncture, or a severe suppurating or septic lesion. In *idiopathic* or *rheumatic* tetanus no wound is visible, but it is probable that some breach of surface or mucous membrane has escaped observation. *Tetanus neonatorum* occurs in new-born infants, the umbilical cord being the seat of infection; *tetanus puerperalis* in lying-in women, the bacilli being carried generally through negligence to the raw uterine surface. *Cephalic tetanus* follows an injury of the face or head, and is characterised by the presence of facial paralysis, due it is supposed to compression in the Fallopian aqueduct of the facial nerve, swollen as a consequence of ascending neuritis. From a prognostic point of view it is important to distinguish between *acute* and *chronic* forms of tetanus. A case is acute if (*a*) the incubation is short, under seven days, and (*b*) the onset of *general* spasms quick, twenty-four to forty-eight hours; it is chronic if (*a*) the incubation is prolonged, eight to fourteen days, and (*b*) the onset of *general* spasms delayed or absent. The general mortality of tetanus is about 45 to 50 per cent., that of acute cases being about 80 to 90 per cent., and of chronic cases 15 to 20 per cent.

Diagnosis.—From strychnine poisoning and hydrophobia, tetanus is distinguished by the spasms being of a tonic instead of a clonic character, and further from hydrophobia by the absence of hallucinations and the discharge of viscid saliva, signs which are characteristic of that affection.

Treatment.—Hitherto the treatment has consisted in attempting to tide the patient over the first few days in the hope that the affection might become less acute and gradually wear itself out. Thus little or nothing could be done beyond supporting the strength with fluid nourishment, administered by the rectum if the patient is unable to swallow, and preventing the spasms as much as possible by the most absolute quiet, the avoidance of all sources of irritation, the employment of such sedatives as chloral or opium, and relieving the constipation by purgatives and enemata. Curara, Indian hemp, Calabar bean, eserine, and numerous other drugs internally, and subcutaneous injections of carbolic acid ($\frac{1}{6}$th of a grain), paraldehyde, pilocarpine and urethane, have all had their advocates, and cases have been reported in which success was attributed to their use. The treatment of tetanus, however, has through the recent researches of Behring, Kitasato, Tizzoni, Cattani, Roux, Vaillard and others, been placed on a different footing, and the injection of the tetanus antitoxin, with the excision of the wound, is the only rational treatment. It has been found by these observers that the blood serum of animals rendered highly immune to tetanus by previous injections of the tetanus-poison (*tetano-toxin*) taken from artificial cultures of the bacilli, possesses the power when injected into another animal of destroying the toxic properties of the tetano-toxin, or of conferring immunity on the animal even though twenty or thirty times the amount sufficient to kill be injected. In an ordinary case of tetanus, however, the injection of the antitoxin is not sufficient, in that fresh doses of the poison are continually being generated by the bacilli in the wound, and absorbed into the system. On the earliest signs of tetanus, therefore, the wound should be freely excised or amputation performed before the antitoxin treatment is begun. The antitoxin should be injected subcutaneously into any part of the body, preferably the abdominal walls or the inner part of the thigh, or, in order that the antitoxin may act more directly on the nerve-centres, it has been injected through a lumbar puncture into the spinal canal, or, after trephining, directly into the brain. The dose will depend upon the severity of the case, the period of the disease at which the treatment is begun, and the quality of the antitoxin used. It must be large if the case is severe and if treatment has been delayed for some days after the symptoms have come on; but results with the antitoxin as at present manufactured have not been good. Moreover, it must be remembered that the antitoxin is an immunising and not a curative agent, hence it should be employed on the earliest appearance of the disease. In preparing and injecting the antitoxin, care

must be taken that it does not come into contact with chemical antiseptics or heat, since both impair its action. Ten cc. is the dose for intra-cranial injection, larger doses are given subcutaneously; also intra-venous and rectal injections have been used. In one case 285 cc. were given per diem, altogether 3,400 cc., and recovery followed.

Diphtheria.—The organism, the *bacillus diphtheriæ*, sets up a fibrogenous inflammation, giving rise to a membrane of fibrin which adheres closely to the surface of the mucous membrane or wound upon which the organism has been inoculated. The organisms are stained with methylene blue, also by Gram's method, but will be decolorised if treated too long with the iodine and iodide solution. A pure culture sets up a local hæmorrhagic œdema, and quickly proves fatal to guinea-pigs if inoculated subcutaneously. It can also be inoculated upon the mucous membrane of the conjunctiva and vagina of rabbits and of the trachea of guinea-pigs and pigeons. The toxin produced can be collected by precipitating it by alcohol as a white powder, which sets up at the site of subcutaneous inoculation a hæmorrhagic œdema and tissue necrosis, with other evidences of septic intoxication, pleural exudation, nephritis, fatty liver, and paralysis. Other animals, such as the horse, being relatively immune, can be infected with more and more virulent cultures, and thereby a venesection serum can be obtained from them having high antitoxic properties.

Most commonly the diphtheria bacillus is inoculated upon and develops in the fauces, forming a whitish fibrinous membrane with leucocytes, attached to the mucous surface, followed by a marked indurated swelling of the neighbouring lymphatic glands, and by symptoms of intoxication by the toxins absorbed. The local affection is liable to become complicated by streptococci or staphylococci (see *Diphtheria of the Larynx*). Diphtheria may attack the nose acutely, or form chronic membranous rhinitis in which bacilli are found. These were formerly called pseudo-diphtheritic, but are now held to be true diphtheria bacilli in a relatively inactive state, but capable of setting up acute diphtheria in a susceptible patient.

Diphtheria of wounds, due to the inoculation of the diphtheria organism upon a wounded surface, is generally seen on the margins of a tracheotomy wound, but instances of chance inoculation occur. The affection is not attended by any marked local symptoms except the covering of the surface of the wound with a fibrinous membrane; there is only slight inflammation around. After peeling off the membrane the surface may be wiped with a strong antiseptic, iodoform dusted on, and antitoxin administered.

The wound-diphtheria of former days was a mild form of phagedena or hospital gangrene.

For the general effects of the toxin upon the Nervous System and Kidneys, see a work on Medicine.

Organisms causing Sloughing and Gangrene with or without the formation of Foul Gases.

Anthrax, Malignant pustule or Charbon is a specific infective disease due to the inoculation with the *Bacillus anthracis*, obtained from cattle or sheep suffering from splenic fever. It occurs most frequently in this country amongst those whose work brings them into contact with hides, wool and rags imported from countries in which splenic fever is common. The bacillus may enter the system through a wound or abraison of the skin made in slaughtering, skinning, or examining animals, or by the prick of large flies, a pustule occurring at the point of inoculation. The bacillus may then remain localised, or it may enter the blood and there rapidly multiplying give rise to a true septicæmia or hæmic infection. At times the bacillus is absorbed directly into the blood through the alimentary or respiratory mucous membrane without any external manifestation, and sets up similar constitutional symptoms, the affection being then known as *Woolsorter's Disease or Anthracæmia*. (See a work on Medicine.)

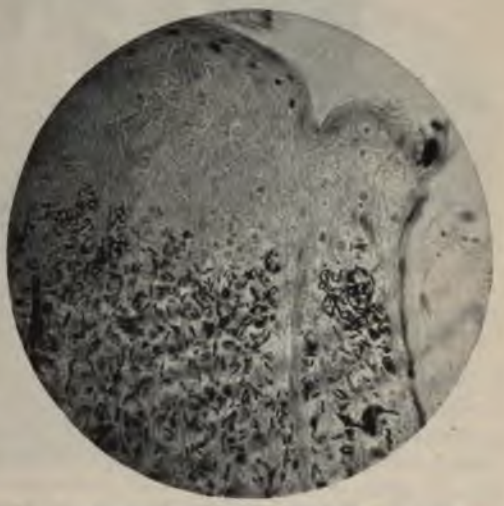

Fig. 32.—Photograph of a vertical section through an anthrax pustule. Bacilli crowd the intercellular spaces of the skin.

Symptoms.—The organisms develop in the intercellular spaces of the skin (Fig. 32). A red itching pimple is first noticed, generally at the situation of a slight scratch or abrasion of the skin, on the face or some other exposed part. The pimple soon becomes converted into a vesicle, whilst the surrounding tissues become red and brawny. Gangrene occurs at the focus of inflammation, and around this a ring of secondary vesicles forms. Thus, when the so-called pustule is fully developed, it presents a very characteristic appearance (Fig. 33). In the centre there is a dry black slough, around this a ring of vesicles, and around this again an area of redness, brawny induration and much œdema. There is, however, but little pain and no suppuration. The neighbouring lymphatic glands may now

become enlarged and tender; feverish symptoms, rapidly assuming a typhoid type, set in, and the patient dies of sudden syncope, exhaustion, coma, or, it may be, of œdema of the glottis when the disease affects the neck. Should any doubt exist as to the nature of the disease, it will be cleared up by examining the contents of the vesicles for the bacillus.

The *Bacillus anthracis* (Fig. 34) is a straight rod-like body, varying from 3 to 10 μ in length and 1·0 to 1·5 μ in breadth. In artificial cultures it grows out into long threads made up of bacilli, the adjacent ends of which are sharply cut and slightly concave. It

Fig. 33.—Malignant pustule. From a case under the care of the late Mr. Morrant Baker.

multiplies by fission and, when in contact with oxygen, by spores. It is readily killed by heat and by a 1 per cent. solution of carbolic acid, but the spores resist heat and drying and a 5 per cent. solution of carbolic acid, though they are destroyed by prolonged boiling, by a 1 per cent. solution of corrosive sublimate and by some other antiseptics. The bacillus is occasionally also found in the blood and in various tissues of the body.

The *treatment* consists in the free excision of the pustule. If this is done in time the patient usually recovers. Some merely scrape with a Volkmann's spoon; others cauterise the wound, after excision or scraping, with chloride of zinc or carbolic acid, or after injecting 1 in 20 carbolic acid around. Dusting with de-emetised ipecacuanha, together with its employment internally after the

excision of the pustule, is highly spoken of by some surgeons. When constitutional symptoms have developed, the strength must be supported by fluid nourishment and by stimulants when indicated. Success has been attained by administering anthrax antitoxin in the earliest stages, combined with the carbolic-acid injection. Indeed, some patients show great resistance to the organism.

The Colon bacillus.—*The Colon bacillus* is normally found in the intestinal tract, and resembles closely in appearance the bacillus of typhoid fever. It seems in the colon to be a harmless saprophyte, but on occasions, such as intestinal obstruction or strangulation and perforation of the bowel, it invades the peritoneum and sets up suppuration, or else does so in conjunction with other organisms. When grown in broth it gives rise to indol and to gas, and turns milk sour and coagulates it. It can invade inflammatory foci in the neighbourhood of the intestine without there being any actual lesion of the mucous tract; hence it may be found complicating pelvic, kidney, gall-bladder, and pleural inflammations. More rarely metastatic inflammations have arisen. These suppurations are attended by the production of gas, of a foul, more or less fæcal odour, and by a greyish sloughing of the tissues.

Fig. 34.—The anthrax bacillus. × 1,000. (After Sternberg.)

The bacillus of malignant œdema (the Vibrion septique of Pasteur).—This organism is seen in action when an infusion of garden mould is injected into a mouse or guinea-pig. There follows a rapid growth of the bacillus and progressive œdematous swelling, with extension by septicæmia to the serous membranes and spleen. It is thought that this organism, derived from garden earth, etc., by chance inoculation, may set up gangrenous processes, with hæmorrhagic œdema and production of gas.

The Bacillus aërogenes capsulatus *of Welch, also called* **the Bacillus phlegmonis emphysematosæ** *of Fraenkel.*—Fraenkel cultivated an organism from a man who had been wounded by a splinter and had died of a gaseous phlegmonous inflammation. He injected it into guinea-pigs and sparrows, producing in them a similar process, by subcutaneous inoculation, in rabbits and guinea-pigs by intra-venous injection; there followed a development of gas in internal organs. Later Welch demonstrated the organism in gaseous abscesses and in emphysematous gangrene.

Hospital gangrene or sloughing phagedæna is a rapidly spreading, infective inflammation accompanied by extensive sloughing and ulceration, affecting an open wound. It is seldom seen at the present day, owing to improved hygiene, better hospital

management, and the more scientific treatment of wounds. The organisms may be conveyed to the wound by the air, the hands of the surgeon or nurse, instruments, sponges, etc. In addition micrococci (*streptococci and staphylococci*) are found in chains and masses as well as singly, both in the slough and in the inflamed tissues around. (See also *Phagedænic Ulcers*, p. 34.) No micro-organisms have been found in the blood.

Symptoms.—When an open wound is attacked, a pultaceous, ash-grey, adherent slough forms on the surface, and the sloughing rapidly spreads both deeply and widely. The edges of the wound are dusky-red, œdematous, sharp-cut and rapidly melt away as the gangrene proceeds. The discharge is thin and greenish or blood-stained, and exhales a horrible fœtor. Although a local infective disease, severe constitutional symptoms of blood-poisoning, rapidly assuming a typhoid character, are set up by the absorption of the septic products, and frequently terminate fatally in a few hours.

Treatment.—The patient should be isolated, and where the disease occurs in military practice as an epidemic, the whole of the patients in the infected building should be removed to huts or tents. Stimulants, opium, and quinine should be given internally; whilst locally, the slough must be completely removed, the ulcerated surface thoroughly destroyed by strong antiseptics, and the wound sprinkled with iodoform and dressed antiseptically

Bacillus of typhoid fever giving rise to surgical complications.—The *bacillus of typhoid fever* is closely allied to the colon bacillus, but differs from it in not producing indol in a broth culture, nor gas on adding grape sugar, and milk is only soured feebly without being coagulated. A toxin is produced which causes bactericidal substances to originate in the blood, so that the serum of a patient suffering or convalescing from typhoid fever will kill bacilli growing in a broth culture, causing them to agglutinate, clump, or collect in a heap (Widal's reaction). The bacillus escapes from the body by the fæces and urine, and then remains viable and active in polluted water. It can also live in fæces for months; it has been found in a dead body ninety-six days after burial; it has remained alive for eighty-two days in sterile sand. Hence its transmission can take place by fæcal or urine contamination, water, dust, or directly to the attending nurse through soiling the hands.

The *surgical complications* may occur in the acute stage of the illness, the typhoid bacillus being found in the blood, spleen, urine, etc., even when there is no intestinal lesion. But it is especially after ulceration and perforation that there are early complications; the bacillus, however, may lie latent in the human body for months or years before giving rise to a lesion such as an abscess or bone disease, from which pure cultures of the typhoid bacillus can be then obtained, showing the pyogenic faculties of the bacillus. In other cases occurring closely in connection with the acute fever, the typhoid

bacillus has not been discovered, but only pyogenic organisms, which have presumably entered the circulation through the intestinal ulceration. In other cases, again, there is a mixed infection. The complications will be here but briefly referred to. The most important is that of *intestinal perforation*, occurring in the third week of the fever (see *Diseases of the Intestines*), followed by general peritonitis, and exceptionally by a limited suppuration. *Cholecystitis* is common, giving rise to temporary jaundice, less often terminating in ulceration and perforation of the gall-bladder, which has become distended by pus. *Appendicitis* may be set up, or a *perigastric*, or *subphrenic*, or *splenic abscess*. *Perichondritis* may occur in the larynx, and may cause such swelling as to necessitate tracheotomy, or may induce laryngeal paralysis, or set up extensive ulceration and necrosis of the arytenoid cartilages followed by stenosis. *Periostitis* and *osteomyelitis* appear most commonly in the tibia or ribs; any slight injury may localise the inflammation. This complication may subside or intermit; on the other hand, suppuration may follow quite late. In the shaft of a long bone, such as the tibia, there may be a collection of pus beneath the periosteum, connected by a narrow channel with a second cavity in the bone, the shape of the two being that of an hour-glass, dumb-bell, or shirt-stud. With further pyæmic complications there may be extensive necrosis. Glandular inflammation may be excited, *parotitis*, *mastitis*, *orchitis*, or more rarely *thyroiditis;* the inflammation may then resolve, or suppuration follow on.

Phlebitis may occur in the veins of the lower limbs, sometimes as an aggravation of previously existing varicose veins, which enlarge and suffer from intermittent attacks of inflammation, or as a partial thrombosis of the main veins in one or both limbs, the femoral vein forming a painful cord, and the limb remaining swollen and œdematous. When the thrombosis causes complete obstruction, *moist gangrene* may suddenly supervene. A limited *dry gangrene* of an extremity sometimes occurs as the result of simple exhaustion. *Synovitis and arthritis* may arise in joints, tendon sheaths, and bursæ, the inflammation being serous, of a rheumatic type, and tending to slowly subside, but in some cases ending in suppuration. One or many joints may be affected. *Pyæmia* may follow typhoid fever, producing *otitis media purulenta*, *thoracic empyema*, *pylophlebitis*, *liver* or *cerebral abscess*, or *meningitis*, also extensive septic inflammation of bones and joints; but in such cases the organisms appear to be purely pyogenic, without the typhoid bacillus taking part, the pyogenic organisms entering through extensive intestinal ulcerations.

Infections Produced by Parasitic Worms.

Filariasis.—The tropically endemic inflammations and obstructions of the lymphatics which give rise to chyluria, chylous hydrocele

and ascites, lymphocele, also to lymphangitis, cellulitis and lymphorrhagia, resulting in elephantiasis, are due to the presence of the worm, *Filaria sanguinis hominis nocturna*, in the lymphatics and glands. The worm is inoculated by means of the mosquito, *culex fatigans*, and passes thence to the lymphatics of the trunk, where masses of the worms, each about 75 mm. in length and of both sexes, are found in the tributaries of the thoracic duct. The young embryos escape into the lymph stream and enter the circulation through the thoracic duct late in the evening. If a drop of blood be taken in the evening before midnight, and examined either wet, or as a film dried and stained with methylene blue, numerous embryos about 0·3 mm. in length will be found. It is not known where these embryos rest by day, nor why in some cases an inflammation is set up, whilst in others the presence of the worms gives rise to no disturbance. Manson's theory of the intermittent attacks of fever to which the patients are subject is that it is due to abortion by the female parasite of immature embryos.

Chyluria.—The urine has a milky appearance, generally clots and settles into three layers, the upper whitish and fatty, the middle pinkish-red containing fibrin, the lowest reddish from blood débris. In it embryo filarias are found. The urine contains a large amount of albumen. Chyluria is usually connected with the presence of the parent worms in the commencement of the thoracic duct, and may co-exist with a peritoneal or pleural chylous exudation.

Lymphocele and lymphadenocele consist of varicose lymphatics and enlarged inguinal and femoral lymphatic glands. The enlargement occurs about puberty, the swellings being partly solid and partly cystic, containing chylous fluid. The swellings are reduced by pressure and on lying down, and enlarge again on standing. They are subject to recurrent attacks of inflammation, resulting from the irritation of the contained worms. Sometimes they subside, sometimes a chylous fistula forms, in many cases elephantiasis slowly develops.

Elephantiasis affects the legs, scrotum and prepuce ; in the female the labia and clitoris, also the breast. In Fiji, localised patches of the skin develop into pear-shaped tumours. The complication commences by an attack of lymphangitis resembling erysipelas, with acute fever often ushered in by a rigor. The fever subsides in a day or two with profuse sweating, or even a discharge of lymph from the skin, and some thickening of the skin and subcutaneous tissue is left. A second attack soon follows, with increased thickening of the skin, which becomes gradually more and more rugose. The skin and subcutaneous tissue are enormously thickened by spongy, œdematous connective tissue, with dilated lymphatics and veins. Fistulous sinuses discharge lymph, and septic ulcerations favour the recurring attacks of inflammation, and the patient suffers more and more from septic absorption and exhaustion.

Filaria loa is a worm found on the West Coast of Africa, about one and a half inches in length and the thickness of a fiddle-string, which lodges in the eyelid or conjunctiva. It can be removed with a needle or through a small incision.

Filaria medinensis, or the **Guinea worm** is met with in India and Southern Asia, also in tropical Africa and America. The embryos develop in a freshwater cyclops, and so gain entrance into the human intestine. The worm develops in the subcutaneous and intermuscular tissue, but passes unnoticed until it has reached the length of about six feet, and has drilled its way head first downwards to the leg, ankle or foot, where a bulla and then a superficial ulcer forms. On contact with water a mass of wriggling embryos are discharged, each about half a millimetre in length, which have been followed into the *cyclops*. In addition to the bulla and ulcer, the worm may be felt beneath the skin, and may give rise to an urticaria with vomiting. When the worm is broken up in the tissues, an acute multilocular abscess with sloughing and fever follow. The older method of treatment was to allow the worm to empty itself, for then it begins to emerge spontaneously, when its body as it emerges can be twisted upon a match, a little every day, without rupturing it. When felt distinctly coiled up beneath the skin, it has been carefully cut down upon. The safest way is to inject perchloride of mercury, 1 in 1,000, into the track of the worm, which kills it, and it is absorbed without local or general inflammation. Sometimes it dies spontaneously and undergoes a calcareous change without piercing the skin.

Fig. 35.—Bilharzia ovum. (Drawing by Dr. W. Lazarus-Barlow.)

Fig. 36.—Bilharzia embryo. (Drawing by Dr. W. Lazarus-Barlow.)

Bilharzia hæmatobia.—The disease caused by this worm is chiefly seen in Egypt and neighbouring parts of Africa and Arabia, in Mesopotamia, and Cyprus. There is at first severe vesical and urethral tenesmus followed by hæmaturia, or the bowels are affected by a dysenteric affection with the passage of blood, mucus and scybala. The ova are found in the blood-clot passed along with threads of mucus in the urine. They are shaped like a melon-seed, about 0·1 mm. in length, with a spine at one end, and contain the embryo.

It is believed that infection must occur through the skin about the anus and urethra in river bathing, for the disease is not seen in infants, young children and European females. Native women who do not bathe have frequently to ford streams and to wade into water to fill their pitchers.

There is a period of incubation, for the disease has developed some time after leaving the infected country.

The parent worms, male and female, are found in the smaller branches of the portal vein, whence the females are believed to move into the smallest vessels of the genito-urinary system to deposit the eggs, which are the cause of all the harm. These ova block vessels, cause blood stasis and local inflammation, and ragged ulcerations, which become encrusted by deposits of ammoniacal urine.

Many of those affected do not suffer greatly. In South Africa the disease is very common among boys, who generally recover. In Egypt it is more severe, causing a large mortality in males. Stone in the kidney and bladder, obstruction of the ureters with pyo-nephrosis, fibro-adenomatous and carcinomatous tumours of the bladder and rectum are common results.

Echinococcus and hydatids, see *Cysts.*

TUMOURS AND CYSTS.

Whilst clinically the term *tumour* is often used as if synonymous with swelling, yet when employed in its more limited sense the swellings caused by inflammation, such as syphilis and tubercle, also mere hypertrophy of a normal tissue or organ, are excluded. *Cysts*, under which very different pathological formations are collected, will be considered separately. There remain the tumours proper. A tumour to the naked eye, both in its external conformation and internal structure, is atypical; it differs from any normal tissue or organ. The elements, however, of which a tumour is composed superficially resemble the normal tissues and cell elements of the body, either in their mature or immature state. Thus, the tissue elements of a tumour resemble bone, cartilage, fat, embryonic mesoblast, etc.; whilst the cell elements are like epithelium or endothelium, but are arranged in a way different from any normal structure. The tissue of a tumour, unlike normal tissue, serves no useful purpose, but the reverse.

Development.—Tumours arise by the multiplication of pre-existing cells. The cells divide by regular or irregular karyokinesis, and new blood-vessels are formed by budding out from the previously existing vessels. Tumours appear to retain throughout their growth the type of cells from which they start, thus epithelial tumours retain the special type of epithelium, columnar, stratified, squamous, or glandular, from which they spring. Tumours

arising from fibrous tissue, fat, cartilage, are composed of cells resembling respectively these tissues. But tumours arising in any form of connective tissue may originate a growth consisting of tissue, resembling the undifferentiated mesoblast of the embryo (*sarcoma*). Moreover, all tumours set up inflammatory changes with the development of fibrous tissue. This may be limited to the boundary zone between the tumour and the healthy tissue around, so forming a capsule. Also, an inflammatory emigration of leucocytes may more or less infiltrate the tumour between its own cell elements, and with the advent of pyogenic germs suppuration may ensue. In epithelial tumours, whilst in many cases the tumour cells seem to act as irritants, like foreign bodies, and set up inflammation, there is also amongst the epithelial-cell elements a variable amount of tissue resembling connective tissue, the origin of which is doubtful. It may be due to inflammation or to the same influence acting on the connective-tissue elements as is acting on the epithelial, or it may be caused by a direct change of the epithelial cell into this form of fibrous tissue.

The proliferation of cells goes on in tumours by karyokinesis often quite regularly, but the mitosis may be irregular, asymmetrical, or multipolar, producing abnormal masses of chromatin from fragmentation of nuclei, whilst direct division of the nucleus has been described, also endogenous cell formation, *i.e.*, one or more daughter cells developing within the mother cell until liberated by the rupture of the latter (see Fig. 53).

Classification.—Failing any certain knowledge as to causation, tumours have been classified on an embryological basis into:—

(1) Mesodermal connective-tissue tumours.

(2) Epithelial tumours, derived from the epithelium, not only of the epiderm or epiblast, and endoderm or hypoblast, but also in the case of the kidney, genital organs, pericardium, pleura, suprarenal body, blood-vessels and lymphatics from the endothelium of the mesoderm, the last two forming an intermediate class of endotheliomata.

(3) Teratoid tumours, which contain structures derived from all three layers.

But owing to the impossibility of making the structure of tumours conform to this classification; and also taking note of the objection that this embryological classification selects an arbitrary period of development, viz., the period when the embryo consists of three layers, whilst only two classes of tumours are made, thus ignoring the development of the epithelium of the genito-urinary tract from mesoderm; also that neuromata and gliomata resemble embryonic connective-tissue tumours, whilst arising in epiblastic structures: the embryological classification has to be combined with a histological one, and also with a clinical one. Histologically, tumours are divided according to the tissue they most resemble. When they

have been cultivated from tumours, but they set up nothing except inflammation when inoculated into animals. These inflammatory results of animal inoculation have been mistaken for new growths. Irregular cells in tumours have been mistaken for protozoa, and likened to psorosperms, such as set up the parasitic disease of the liver in domesticated rabbits, although on examination of such livers, it will be seen that the process is entirely an inflammatory one.

(6) *By uncontrolled cell-proliferation.*— The development in an atypical manner of cell elements, which in themselves closely resemble normal cells, has suggested the theory that some influence, nervous or other, normally controlling and directing cells, is taken off, so that the cells continuously proliferate. A cell may be considered to be under the restraining or tonic influence of surrounding cells and tissues, and that when this is removed it continues to grow and divide freely. In support of this theory, changes in connection with old age are mentioned. The connective tissue of the skin and subcutaneous tissue atrophies and becomes looser, whilst epithelial cells retain activity, or even become more active, *e.g.*, new formation of hair about the ears, eyebrows, nasal orifices. However, this theory does not at present carry us beyond the fact of the continuous atypical development. Nerve paralysis does not lead to tumour development.

(7) *Developmental tendencies.* — All ill-developed tissues are especially prone to develop tumours, sometimes before, often long after, puberty. An ill-formed breast with a retracted nipple often becomes the seat of malignant disease. Warts and moles on the skin give rise to growths by proliferation of the cells composing them. Congenital remnants of fœtal structures in the kidney and ovary become the seat of malignant disease. Some tumours, indeed, may be regarded as local malformations. But in many cases there is no evidence of the existence of embryonic tissue, so that the theory, called Cohnheim's, that tumours arise in embryonic rests, can only be of partial application.

(8) *Inherited or acquired tendencies.*—Hereditary tendencies are rarely transmitted direct from father or mother to offspring. Sometimes several members of a family suffer from tumours, more often there is a vague account of some more or less distant relation having been affected. But even then the tumours so connected are rarely of the same kind, and hence the influence of heredity must be very slight. Tumours tend to develop at various ages, sometimes in connection with the active growth of early life, more often during the slow degeneration attending advancing age. They appear to arise sometimes in connection with depressing influences, as grief, anxiety or mental strain, or from physical exhaustion.

Clinical course.—Clinically, tumours are spoken of as innocent and malignant. They are liable to secondary changes, also to recurrence and dissemination.

Innocent tumours, as a rule, grow slowly, and resemble the fully-formed tissues of the body, and usually those amongst which they grow. They are generally encapsuled, circumscribed, and freely movable, merely *displacing* the tissues around, not infiltrating them. They do not involve the lymphatic glands, nor become disseminated in distant organs; neither do they recur if completely removed. They may, however, attain a large size and destroy life by pressing upon a vital organ, or in other ways interfering with its functions.

Malignant tumours, on the other hand, grow rapidly, do not resemble the fully-formed tissues in structure, and differ markedly in appearance from the tissues in which they grow. They are generally non-encapsuled and *infiltrate* and replace the surrounding parts, whether these be muscle, fat, bone, etc., and in consequence become more or less fixed and adherent. They frequently involve the lymphatic glands, and become disseminated through the body by means either of the lymph- or blood-stream. They usually recur after removal, in the scar, in the corresponding lymphatic glands, or in internal organs, and sooner or later give rise to a general cachectic condition depending upon septic or other absorption and known as the *cancerous cachexia*.

Secondary changes are common in tumours, especially in those of more rapid growth. Thus a tumour may become inflamed, or may ulcerate, or undergo fatty, mucoid, colloid, pigmentary, or calcareous degeneration; or as the result of these changes, or of hæmorrhage into its substance, cysts, or, more rarely, circumscribed abscesses, may form in its interior; or the whole tumour may undergo atrophy or necrosis, and, in exceptional instances, slough away. At times a tumour, at first innocent, may after a longer or shorter period become malignant, as, for instance, a papilloma degenerating into an epithelioma.

Recurrence and dissemination.—Local recurrence is probably the result of some of the tumour elements having escaped removal, and may take place in the scar, or in the tissues immediately around. Reproduction in the neighbouring lymphatic glands is believed to be due to the tumour cells becoming arrested in the lymph sinuses; dissemination in more distant tissues and organs to the tumour cells being carried by the blood-stream (which they may enter either directly, or indirectly by the lymph channels) to these parts, where they become lodged, and form starting-points for secondary growths. Secondary growths, whether in the glands, or elsewhere, resemble in structure the primary tumour.

Anomalies in the clinical course of malignant disease, see p. 144.

The **Classification of tumours** (see p. 117) is based upon their structure, also upon their clinical characters. But the structure often proves to be a mixed one. The tumour may then be considered to have developed in the first place from one structure which controls

generally its clinical course, but to have entailed a secondary growth of another; or originally growing from one, a metamorphosis or degeneration has given rise to secondary changes.

(A.) Connective-tissue Tumours.

Innocent Connective-tissue Tumours.

1. **Fibroma or fibrous tumour.**—*Development.*—Fibromata or fibrous tumours are composed of tissue more or less closely resembling the normal white fibrous tissue. They originate from a previously existing connective tissue, by division of cells and formation of fibrils, as in the development of the normal tissues, but without forming elastic fibres, except occasionally near blood-vessels. They generally develop from one centre; less often a number of small tumours may be united into a common mass. The consistency of fibrous tumours is very variable. Some, called *Desmoid tumours*, are hard and tough, grating on section; the fibres are arranged concentrically or in whorls, appearing as a glistening white tissue resembling tendon or aponeurosis. They are composed microscopically of coarse fibrils arranged concentrically or interlaced (Fig. 37), between which lie, in parallel rows, cells with elongated nuclei, and only a few blood-vessels. Others are soft, more vascular, greyish-white on section, and composed of, fine loosely-arranged fibres, and numerous connective-tissue corpuscles, with large round or oval nuclei. Hence these tumours have been called *fibro-cellular tumours*. Serous fluid can be squeezed out from their cut surface. They may be encapsuled or be continuous with surrounding fibrous tissue without any definite line of demarcation.

Fig. 37.—Fibrous tumour. Firm variety.

Clinical varieties.—When growing in the skin or subcutaneous tissue they form circumscribed sessile or more or less pedunculated tumours, often multiple and scattered over the body, called *molluscum fibrosum*. They may tend to ulcerate and bleed when pedunculated; when they do so they should be excised with the pedicle, otherwise they may be let alone.

Pachydermatocele is a diffuse fibroma, causing the skin to become rugose and hang in folds. It affects especially the scalp, but also the skin of the trunk and limbs. The growth ultimately tends to become sarcomatous, and should therefore be excised and the area covered by skin-grafts, if this is in any way practicable.

Soft fibromata grow from the periosteum of the gum (*fibrous*

epulis); from the nose and naso-pharynx, where they become dependent (*naso-pharyngeal polypus*), and large veins developing about the pedicle, tend to cause hæmorrhage. In the breast fibromas develop with a more or less concentric arrangement round the canaliculi and remains of the alveoli, without any sharp demarcation from the remaining connective tissue of the breast. When only a little of the glandular element is enclosed in the tumour, it may be called an *adeno-fibroma*; when this is considerable and in excess of the fibrous tissue, *fibro-adenoma*. In some cases, at any rate, carcinoma supervenes. Their excision, including some of the surrounding breast tissue, is required; in cases of doubtful malignancy, the whole breast. In the uterus and annexa fibromas develop around the blood-vessels, more or less in combination with the unstriped muscle of the uterine wall, of the tube and round ligament, being called *myo-fibroma* or *fibro-myoma*, according as the fibrous tissue or the muscular fibres are in excess; or simply *fibroids*. When combined with dilated vessels, arteries, or veins, they are known as *angio-fibroma*; less often the fibrous tissue surrounds dilated lymph spaces (*fibro-lymphangioma*). A fibroma may develop singly within the sheath of a large nerve (*neuro-fibroma*), or may be found scattered on many nerves, especially the cauda equina, or it may grow near the terminal end of a sensory nerve forming the painful *subcutaneous nodule*.

Fig. 38.—Fatty tumour.

Occasionally fibromata grow from deep connective tissue, inter-muscular or periosteal, or from the fibrous capsule or septa of organs. All the fibrous tissue of an organ may be involved by the tumour growth. In the ovary they may arise in the scar of a corpus luteum. These fibromata form smooth, painless, encapsuled homogeneous tumours, distinguished from gummata by the appearance of a cross-section, and from fibro-sarcomata by their slow growth and non-recurrence after being removed.

Keloid is a peculiar form of fibrous new growth (see *Cicatrices*).

Secondary changes.—The connective tissue changes into fat, or undergoes myxomatous degeneration, with a tendency to form cysts, into which blood may extravasate, or a fibroma may gradually calcify.

Lipoma.—*Development.*—Lipomata or fatty tumours develop from the connective-tissue cells, which in most cases contain fat, except in places like the skin of the scrotum and meninges. The fat-cells of the tumours resemble the normal (Fig. 38).

Clinical varieties.—Common fatty tumour.—The commonest type of fatty tumour grows from the subcutaneous tissue, and, like it, is divided into lobules separated by fine septa of connective tissue. It is closely attached to the under-surface of the skin, which is somewhat puckered or dimpled by the growth. From the deeper

structures the tumour is separated by a fine fibrous-tissue capsule. It has only a small blood-supply. These tumours develop in adults on the shoulders, back, and buttocks, where they have been attributed to irritation; but the rubbing of clothes, braces, etc., appears rather to stimulate growth already started. They are felt to be soft, elastic, semi-fluctuating, painless, generally single, the edge slips away under the pressure of the finger, the skin dimples when pinched up, and there is no escape of fluid on puncturing. These signs serve to distinguish them from a chronic abscess, cyst, or bursa. As they grow they become pendulous, congested, and may then ulcerate. They are removed by making an elliptical incision so as to include the skin to which the tumour is most closely attached, for sloughing might take place if it were dissected up; then the rest of the tumour easily shells out with little hæmorrhage, but care must be taken not to leave behind any lobule, or the tumour will grow again.

Sub-serous lipoma.—When growing from the sub-peritoneal fat, near the internal abdominal ring, it descends by gravity along the spermatic cord to the scrotum; if in the linea alba or elsewhere on the abdominal wall, it forms a small tumour, movable beneath the skin, the pedicle of which passes back through a gap in the aponeurosis (see *Ventral hernia*). Occasionally one is seen to the side of the sternum, protruding between the ribs. *Treatment.*—The tumour is exposed through a linear incision, isolated, and a ligature placed on the pedicle without entering the serous cavity.

Diffuse lipoma shows no capsule or distinct lobulation, and is more vascular than the common circumscribed lipoma. It is a local hypertrophy of the subcutaneous fat with which the margins of the tumour insensibly blend. It is met with in stout people, especially in those addicted to alcohol, and forms rolls of fat at the back of the neck, beneath the chin, masses in the abdominal wall or about the hips. When occurring on a limb, a lipomatous form of elephantiasis ensues. Diffuse lipoma is at first to be treated on the same lines as obesity. Caustic potash, iodide of potassium, or thyroid tabloids may be administered. The patient must abstain from alcohol, avoid fat-forming foods, and take more exercise. Only when markedly impeding the patient's movements should any portion be cut out, and in any case the excision is only partial.

Nævo-lipoma.—Fatty tumours occurring before puberty are of congenital origin, with more or less of nævoid tissue connected with them; they sometimes grow in connection with the meninges, and are met with in spina bifida, when they may protrude externally or lie within the spinal canal. They may form part of a teratoma.

Deep-seated lipomata grow from intermuscular tissue, also in organs such as the breast and kidney.

Lipoma arborescens is the term applied to masses of fat replacing and enlarging the synovial fringes of joints.

Secondary changes.—A lipoma may undergo partial myxomatous degeneration, *myxo-lipoma*, or by increase of fibrous tissue become a *fibro-lipoma*, or undergo ulceration and sloughing.

Chondromata, or cartilaginous tumours grow practically always in connection with bone (see *Bone*). The cartilaginous tumours growing in soft parts are described under Endothelioma, p. 133.

Osteoma or bony tumours, see *Bone.*

Odontomata or tumours of the teeth, see *Teeth.*

Myxomas or mucous tumours consist of tissue resembling that of the umbilical cord, or the vitreous humour. They are composed of delicate fibrils with fluid containing mucin, and stellate cells with oval nuclei. But no tumour arises from normal myxomatous tissue, nor is a tumour wholly composed of it; but myxomatous tumours arise by transformations from others, and such tumours are then called myxo-fibroma, myxo-lipoma, myxo-chondroma, myxo-sarcoma. From fibrous connective tissue they arise by a formation of mucinous fluid between the fibrils, many of which tend to disappear. A common instance is the mucous polypus of the nose. If from fat, the fat globules disappear, and the cells shrink and become stellate, while between the cells the mucinous fluid collects. In the case of a cartilaginous tumour, the hyalin ground substance changes into a mucinous jelly, whilst the cartilage cells become stellate. In a myxo-sarcoma there are in parts masses of cells rapidly dividing, in others a collection of mucin between the cells.

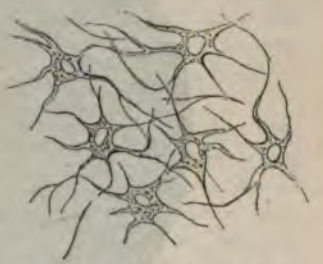

Fig. 39.—Myxomatous tumour.

To the naked eye, myxomatous tissue is of soft gelatinous consistency, is pinkish or greyish-white on section, and a tenacious or glairy fluid oozes from it.

The myxomatous tumours have the characters of the original growth. By degenerating, myxomatous tissue in particular tends to form cysts, into which, by rupture of vessels, blood is very likely to be extravasated.

Hæmangioma, see *Diseases of Arteries.*

Lymphangioma, and

Lymphadenomata or lymphomata, see *Diseases of Lymphatics.*

Myoma.—The *leio-myoma* or *myoma lævicellulare*, is characterised by unstriped muscular fibres, and may occur occasionally in the wall of the intestines, ureter, prostate, and in skin, either from the wall of the blood-vessels or from the arrectores pili, but is chiefly met with in connection with the uterus, also in the wall of the tubes and in the round ligament down to its termination in the labium. It is composed of unstriped muscular fibres mixed with fibrous tissue in

various proportions. Myomas develop from unstriped muscular fibres which form strands of fibres arranged concentrically, in whorls, in waving bands, having on section a greyish-red appearance, or when largely mixed with fibrous tissue a pinkish-white. It is difficult to distinguish a myoma from a fibroma until after macerating in nitric acid or caustic potash, when the spindle-shaped muscle cells with their rod-like nuclei can be recognised. Sections show the fibres cut in all directions, longitudinally, obliquely and transversely (Fig. 40). In the last case the muscle-cell outlines appear as areas of various diameters, with a darkly staining dot in the centre, the size varying according to the point at which the spindle cell and

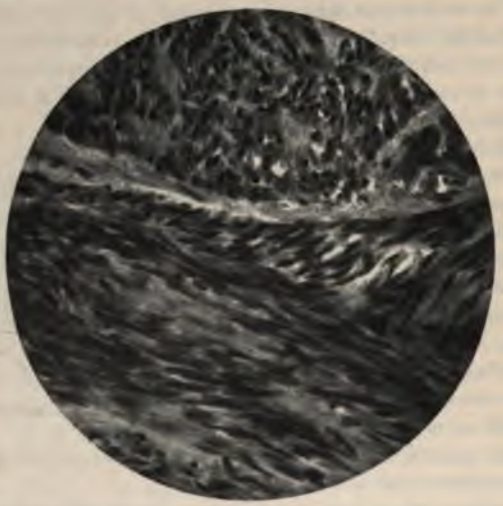

FIG. 40.—Myoma. Photograph of a section through a myoma. In the lower half the strands of unstriped muscle fibres are shown in longitudinal section; in the upper half cut transversely, and between are some fibres cut obliquely.

its rod-like nucleus is cut across. They are separated from their surroundings by a fibrous capsule except when the whole organ, *e.g.*, the uterus, undergoes a change. They may undergo myxomatous degeneration forming cysts, may gradually become more and more fibrous, calcify, or partially change into fat. Likewise they may change into sarcoma.

A myoma or fibro-myoma of the uterus may include epithelial elements, columnar cells and gland tubes from the fundus, squamous epithelium from the cervix, or tubular masses of cells connected with the Wolffian body. Hence the term adeno-myoma.

The *rhabdo-myoma* or *Myoma strio-cellulare* is composed largely of elongated spindle cells with transverse and also longitudinal striations. They are met with in the kidney, testis, uterus, vagina,

bladder, and other places. In the kidney and testis the tumours are of a mixed complicated structure, *teratomata*, or rapidly-growing sarcomata, *rhabdo-sarcoma*.

Neuroma.—A *true neuroma*, composed of nerve-fibres and ganglion cells, has been described, especially in connection with the sympathetic. Mixed with fibrous tissue, it has been met with as a deep-seated tumour in the neck connected with a sympathetic ganglion. *Traumatic neuromas*, or bulbous nerve-ends, form on the cut ends of nerves, and are composed of newly-formed coiled, more or less incomplete, nerve-fibres mixed with fibrous tissue (see *Injuries of Nerves*). *Fibromata* occur on nerves as mentioned above, p. 123. *Neuroma plexiforme*, or *plexiform neuroma*, is due to fibromatous thickening of the sheath of the nerve and of the connective tissue, the endoneurium, immediately around, whilst the nerve fibres are increased in length so as to become very tortuous. Whether there is any new formation of nerve-fibres at all is doubtful; there is certainly none to any great extent. Chiefly medullated, but also non-medullated nerves are affected. Clinically, the tumours form in the skin of the scalp, also in the trunk and limbs, tending to produce fibrous folds and forming part of the condition described as pachydermatocele or elephantiasis.

Glioma.—A *glioma* grows from the neuroglia forming the connecting framework of the central nervous system. In the brain, these tumours may be encapsuled, but also diffuse, showing no line of demarcation from the surrounding tissue. In the spinal cord they develop, especially around the central canal, being widely diffused. On section these tumours may be scarcely distinguishable from the surrounding nerve-tissue, or may appear more vascular, reddish, or actually show cysts containing blood-clot, or simply a glairy fluid from a myxomatous degeneration.

Microscopically they are composed of delicate interlacing fibrillæ and cells, having darkly-staining round or slightly oval nuclei, very little protoplasm and delicate stellate processes. It is the neuroglia cells and not the nerve cells which give rise to the tumour, and the more rapidly it is in growing, the more cellular the tumour, the more the cells show division. In the latter case the connective tissue around the blood-vessels also is involved, and the tumour becomes a glio-sarcoma. The retina and optic nerve is a common seat of glioma (see *Eye*). An encapsuled glioma is a favourable kind of brain tumour for removal (see *Brain*). The diffuse gliomatous degeneration of the spinal cord forming cysts is called *syringo-myelia*, and occasions peculiar trophic disturbances in the bones and necrosis of fingers (see *Bone*).

Malignant Connective-tissue Tumours.

Sarcomata.—The tumours included under the term sarcoma form a varied group, having this in common, that the cells of which they

are composed resemble those of embryonic or immature connective tissue derived from the mesoderm.

In these tumours the cell elements predominate, the intercellular substance being relatively unimportant. The cells, whilst retaining more or less the type of mesoblastic cells, undergo rapid division by regular or irregular mitosis, and rarely divide directly. The intercellular substance when small in amount gives the section of the tumour a brain-like or medullary aspect, the so-called "medullary cancer" of pre-microscopic days; if there is much intercellular fibrous substance, the tumours approach in appearance the fibromata, and were formerly known as "recurrent fibroids."

Sarcomas develop:—(1) From the normal connective tissue, in the skin, subcutaneous tissue, intermuscular, periosteal or glandular connective tissue, from the walls of blood-vessels and lymphatics, from the sheaths of nerves, from the meninges, and from neuroglia.

(2) In previously existing benign tumours, such as fibromas and myomas, and in inflammatory connective tissue, the result of injury with blood extravasation, of syphilis, etc.

(3) In embryonic or young tissue. Some sarcomas are congenital, *e.g.*, in the kidney, or they grow in malformations, and often appear in early life.

A sarcoma generally begins at one spot, but there are exceptions, such as multiple sarcoma of the skin, where a number of tumours develop simultaneously without any sign of being metastases from a primary growth.

Varieties of Sarcomata:

1. *Simple sarcomas* show mainly a variation in the shape of their cells and the amount of intercellular substance. The blood-vessels are little developed, ramifying between the cells with very thin walls, or are mere blood-spaces bounded by the cells.

2. *Partially-organised sarcomata*, alveolar or tubular sarcomata, or mixed sarcomas, so called from their complicated structure, are now generally grouped under the term *endothelioma*, as being developed from the endothelium of capillaries and lymphatics, and giving rise to various structures, blood-vessels, cartilage, cysts, etc. Some approach in structure epithelial tumours, yet clinically take the course of sarcomata.

3. *Sarcomas showing peculiar pigmentary* and other changes in their cells and intercellular substance.

1. **Simple sarcomata.**—The cells are masses of granular protoplasm, without a distinct cell membrane, containing one or more nuclei. The cells are round, large or small, or oval or spindle-shaped, the intercellular substance very scanty, semi-fluid, or consisting of fine fibrillæ irregularly arranged, as distinct from the parallel or concentric arrangement in whorls of the fibrous tissue in fibromata, nor are there definitely formed alveolar spaces, as seen in the carcinomata. The vessels are thin-walled channels formed by the adjacent

cells, not definite vessels ramifying in a stroma. If growing slowly, they may be separated by a zone of inflammatory tissue forming apparently a capsule, yet this is often œdematous and ill-defined, and the growth tends to spread along connective-tissue planes. Extending by the veins, metastases develop especially in the lungs, also in the liver. The rapidly-growing kinds, the periosteal sarcomata in particular, also those in the breast, testicle, and tonsils, quickly cause a soft enlargement of the neighbouring lymphatic glands.

(*a*) *Round-celled sarcomas.*—These may be further distinguished according as they are composed of small or large round cells, and according as they arise in connective tissue or in lymphatic glands.

In connective tissue the round-celled sarcomata form soft, rapidly-growing tumours, composed simply of round cells and thin-walled blood-vessels. The cells have a spherical nucleus, around which is some cell protoplasm. It is therefore difficult to distinguish the tumour at its growing margin from the inflammation which the growth sets up. At the growing margin, bordering on muscle, masses of these cells, arranged in rows, are seen infiltrating the intermuscular connective tissue. But the cells of this growth do not stain so deeply as the inflammatory cells, are larger, and show karyokinesis.

These tumours are most common in the periosteum of bone in the skin and subcutaneous tissue, and in organs such as the breast and testicle. They grow rapidly, invading the neighbouring tissues. As they approach the skin, veins enlarge, the skin over them becomes livid, then gives way in the centre. Through this hole the tumour fungates without the skin being first infiltrated.

The fungation gives rise to septic infection and breaking down of the tumour, so that the patient's general health now begins to suffer, and cachexia sets in. Meanwhile the corresponding lymphatic glands undergo a soft enlargement, then pulmonary trouble appears. The patient presents, *e.g.*, signs of a pleural effusion, which on aspiration yields a serous fluid, much mixed with blood. Then follows increasing respiratory difficulty, enlargement of the liver, appearance of rapidly-growing tumours in various parts of the skin, which in their turn fungate and bleed. Death soon follows.

Diagnosis.—It is difficult to distinguish a rapidly-growing sarcoma from inflammation, started by an injury or due to syphilis. Such a sarcoma often occasions a rise of temperature to 102° F., also, even apart from fungation, it is liable to septic infection from the skin or a mucous surface, causing it to partially suppurate. If the diagnosis lies between subacute inflammation and a new growth, anti-syphilitic measures may be tried, but for not more than ten days when ineffectual, to exclude a gumma. In the case of doubt whether there is acute inflammation and suppuration or a new growth, a grooved needle may be inserted, or, better still, an incision may be made, and a portion of the material at once examined microscopically.

When near one of the large vessels a sarcoma may simulate an aneurysm, not only because it receives a communicated pulsation, but also because it shows to a certain degree expansile pulsation owing to its great vascularity. But it does not shrink in the marked manner that an aneurysm does upon compressing the artery above. When, however, an aneurysm is partly filled by clot it will not empty, and then a consideration of the history and eventually a cautious exploration form the only means of distinguishing the two.

Treatment.—The tumour must be widely removed, including the skin over it, the whole organ and the neighbouring lymphatic glands in the case of the breast or testis. If periosteal, the limb is amputated. But the prognosis of cure is very unfavourable, that in periosteal sarcoma being absolutely bad.

Large-round-celled sarcomas.—These are characterised by the large size of the cells, containing much protoplasm, with large oval vesicular nuclei. Many of the cells show karyokinesis, and contain two or four developing nuclei, with a delicate reticulum between.

FIG. 41.—Large-round-celled sarcoma.

Lympho-sarcoma or small-round-celled sarcoma of a lymphatic gland.—When growing in lymphatic-gland tissue, a small-round-celled sarcoma is called a *lympho-sarcoma*. It closely imitates the structure of the gland as far as regards the cells and the stroma, but the normal arrangement into a cortical and medullary portion is lost, or at least only irregularly indicated. The cells resemble those of a normal gland (Fig. 42); the reticulum, consisting of stellate cells with oval nuclei and interlacing fibrils, varies in amount, giving the tumour a tough or soft consistency, and in it blood-vessels run. The growing margin shows imperfectly an inflammatory form of œdematous tissue. They tend to infiltrate surrounding structures, spreading by the intermuscular connective tissue, or, perforating large veins, extend rapidly along the lumen. They originate in lymphatic glands, in the tonsil, and in other adenoid tissues of the naso-pharnyx, in the Peyer's patches and solitary follicles of the intestine, in the spleen and thymus gland. At first they keep the shape of the gland, causing apparently a mere hypertrophy. Then they extend rapidly to the neighbouring glands, causing pressure in the neck, or in the anterior or posterior mediastinum by surrounding the root of the heart and lungs; or they form masses in the retro-peritoneal tissue.

Diagnosis.—A lympho-sarcoma has to be diagnosed from tuberculosis and lymphadenoma affecting lymphatic glands.

Treatment.—The treatment is removal whenever practicable. As these tumours show great variations in their malignancy, there is always a possibility of cure if they are completely removed.

(*b*) *Spindle-celled sarcomas.*—Spindle-celled sarcomas are a common

type of sarcoma, consisting of spindle-shaped cells of various sizes, so that one can speak of a large- and a small-spindle-celled sarcoma.

The cells are arranged in bands irregularly, not in whorls as in fibromata, and only a few nuclei exhibit mitosis. A very small amount of intercellular substance separates the cells, and this is mainly homogeneous or faintly fibrillar, and shows a very few thin-

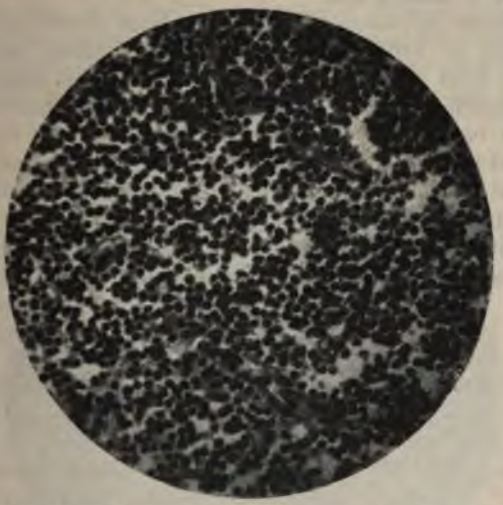

Fig. 42.—Small-round-celled sarcoma or lympho-sarcoma. Photograph of a section showing cells resembling those of a lymphatic gland, between which is a delicate reticulum of fine interlacing fibrils.

walled capillary vessels (Fig. 43). These growths may be enclosed by an inflammatory capsule and separate easily from surrounding structures, or be continuous with them. On section they appear pinkish or greyish-white. Their usual seats are subcutaneous tissue, fasciæ, tendon sheaths, and periosteum. The growing margin is apt to show rapidly-dividing cells, oval or round, infiltrating surrounding parts.

Fig. 43.—Spindle-celled sarcoma.

They are difficult to distinguish from chronic inflammation, especially from gummata. But after a short trial of anti-syphilitic remedies the tumour must be removed. If shelled out they are apt to recur *in situ*, "recurrent fibroids." If this happens a more free removal, involving a normal zone of tissue, should be at once undertaken. Should this not be done there is a danger of fungation and of metastases, which often grow more rapidly than the primary tumour.

(c) *Giant-celled or myeloid sarcoma*, or *mixed-celled sarcoma*.—This is a tumour composed of round, oval and spindle cells in various

proportions, but characterised by exhibiting a number of giant multinuclear cells like the osteoclasts of bone (Fig. 44).

These peculiar cells are irregular masses of protoplasm containing as many as thirty oval nuclei. They have their origin in the giant-cells of bone marrow, and to a smaller extent in those met with in connective tissue of the skin, breast, etc., so that a few are found in sarcomas in these places.

The myeloid sarcomata of bone grow from cancellous tissue and form elastic or soft jelly-like tumours, exhibiting on section a maroon or livid crimson colour, not unlike the muscular tissue of the mammalian heart, with a smooth, shining surface blotched by patches of blood extravasation. As they grow the inflammatory zone around absorbs the normal bone, whilst forming fresh periosteal bone on the surface, so that the tumour appears enclosed in a shell, and the appearance of the bone after maceration gave rise to the term "spina ventosa." Having broken through the shell the tumour begins to spread amongst the muscles, with blood extravasation. Ultimately it will reach the skin and fungate. Only after a long time, *e.g.*, two years, does a tendency to metastasis occur, and then only a single tumour may arise, having the characters of the primary growth.

Fig. 44.—Myeloid sarcoma.

There is great tendency to myxomatous degeneration and blood extravasation. Indeed the whole tumour may become a blood cyst, and communicating with the blood-vessels, it may pulsate, and give rise to one form of bone aneurysm.

For *signs*, *diagnosis*, and *treatment*, see *Sarcoma of Bone*.

Mixed-celled sarcomas.—Chondro-sarcoma, *Osteo-sarcoma*, *Myxo-sarcoma.*—Sarcomas may show in various parts oval, spindle, and round cells. In addition, degenerations may occur. Myxomatous degeneration gives rise to cysts containing serum, mucin, or blood. In the case of bone tumours, cartilage or bone in the tumour may possibly be derived from cartilage or bone cells, but these forms may appear unconnected with bone. A hyalin homogeneous substance collects between and separates the cells, and in this ossification may follow; or the calcification and ossification may proceed directly, as in normally forming bone in membrane. In other cases the presence of a cartilaginous substance points to the tumour being an endothelioma. The presence of cysts, of cartilage or of bone in a tumour is so far favourable as regards prognosis, in that it shows that the growth must have developed slowly. On the other hand, the growing margin of the tumour may exhibit rapidly-dividing round cells, evidence that the tumour is increasing in malignancy. The presence of giant-cells is welcomed as showing

that the tumour probably belongs to the very favourable myeloid type.

2. **Partially organised sarcomata—the endothelioma or lymphangio-sarcoma and hæmangio-sarcoma.—Alveolar or tubular sarcoma.**—Amongst the tumours generally resembling sarcomas in their clinical course, are tumours which, on account of the epithelial-like character of their cells, the partially alveolar arrangement of the stroma (Fig. 45), and the peculiarly variable appearance of different sections taken from the same tumour, have given rise to much controversy as to their classification. They are now thought to be derived from the endothelium of capillaries and lymphatics

Fig. 45.—Endothelioma. Photograph of a section through a parotid tumour. Tubules are seen formed by cells believed to be of endothelial origin filled with a hyalin substance. The darker stained portions are remains of the parotid gland.

the cells undergoing various transformations, but giving rise to tumours generally of a connective-tissue sarcomatous character. The cells, of large size, are arranged in strands and masses, between which is formed a more or less vascular connective-tissue stroma.

(*a*) *Lymphangio-sarcoma or lymphatic endothelioma.* — These tumours develop from the endothelium of lymphatic spaces and lymphatics in normal connective tissue, or from congenital malformations, moles and warts. They also form serous surface tumours growing from the dura and pia mater of the brain and spinal cord, from the pleura and peritoneum. The endothelium lining subarachnoid spaces develops into cubical or cylindrical tubular masses, spreading over the surface and consisting of epithelial-like cells. The pleura and peritoneum may become thickened by a

development of endothelial cells which distend the lymph spaces, the cells showing signs of rapidly dividing. Less often it is the actual lining endothelial cells of the serous surface which give rise to the tumours. But it is in the parotid, breast, testis, and skin where growths of this kind arise, and are of especial surgical interest. The cells have the features above noted of rapidly dividing, endothelial cells forming in strands and masses. But this is only the commencement of the tumour. Between these cells develops fibrous tissue. The connective-tissue corpuscles actively divide to form a

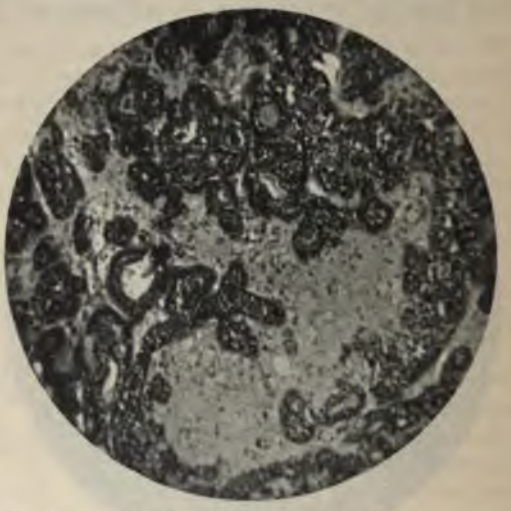

Fig. 46.—Endothelioma. Photograph of a section through a parotid tumour. The hyalin material has run together to produce a substance formerly termed cartilage. By further degeneration cystic spaces result. Some darkly-stained remnants of the parotid are seen.

stroma of spindle-celled sarcomatous tissue. Or between the tubular-like strands of cells collects a hyalin substance, so that it appears to be a secretion of these endothelial cells, and in this respect the tumour much approaches the structure of an adenoma or carcinoma. By an increase of this hyalin substance and a disappearance of cells (Fig. 46), the hyalin substance comes closely to resemble cartilage both to the naked-eye and microscopical examination. But on closer inspection it is seen to possess a more glistening white appearance than cartilage and to have different micro-chemical reactions. This cartilaginous substance readily undergoes degeneration, and so cysts are developed.

(*b*) *Hæmangio-sarcomas, or vascular endotheliomata,* are characterised by developing from the endothelium of blood capillaries; spaces are formed lined with cubical or cylindrical endothelial cells containing

ıd, also new vessels are formed and masses of cells come to round the lumen, whilst the new vessels grow in length, become tuous, and so have a plexiform arrangement. Such tumours are y vascular, and occur in the testis, kidney, salivary glands, ies, brain, mamma, thyroid gland, skin, ovary, liver, and form t of sacrococcygeal and other teratoid tumours. There is no arp line of distinction between the vascular and lymphatic dothelium, and the same tumour may show instances of each.

3. Sarcomas showing peculiar features.—*Melanotic sarcoma.* -The tumour is peculiar in that connective-tissue cells contain pigment, melanin, giving to the tumour a black or greyish-black appearance. The pigment is seen in the cells as sepia-brown or yellow-brown granules, or as a diffuse yellow-brown staining. Some of the tumours have the general structure of a round-celled sarcoma, others an alveolar arrangement and are hence called by some melanotic carcinoma, but they are probably endotheliomata. Melanotic sarcomas grow from the choroid coat of the eye and from pigmented moles of the skin, e.g., of fingers, in which a small dusky ulcer first forms. They are very common in grey horses, originating round the anus. There is a great tendency to early metastasis, the secondary growths springing from one or two points in lymphatic glands or the liver, or from an infinite number of small points in the skin or serous surfaces. When the patient begins to suffer from cachexia the pigment may be found in the urine. *Treatment.*—Free removal of the eye, finger, or a tumour of the skin by a wide excision; but the prognosis is unfavourable, as the operation does not prevent metastases.

Chloroma is a form of small-round-celled sarcoma, which commences in the periosteum of the frontal and facial bones, is attended by marked anæmia, and quickly gives rise to metastases. It is so named from the peculiar grass-green colour of the tumours, both primary and secondary, as seen through the skin during life and on section after death, but which fades on exposure, whilst the rest of the body is not similarly pigmented.

Psammoma, or sand tumour, is a fibro-sarcoma growing in the meninges, vascular plexuses, or pineal body, enclosing peculiar concentric grains of calcareous material, due to its deposition in connective tissue and blood-vessels which have undergone hyalin degeneration.

(B.) Epithelial Tumours.

Epithelial tumours are new growths formed by the epithelium, both of surfaces and glands, together with vascular connective tissue. The general arrangement is that the connective tissue forms either a framework for the covering epithelium or a stroma or network, in the meshes and spaces of which the epithelial cells are placed. They are divided into the *benign* (the papillomas, and adenomas, including the cystic adenomas), and the *malignant* (the carcinomas, including

the cystic carcinomas). But the two are not sharply distinguished; whilst the former are circumscribed and produce no metastases, and the latter infiltrate and undergo metastasis, yet papillomas and adenomas often undergo a change in the rapidity of increase and extension of epithelial cells so as to become carcinomas.

Benign Epithelial Tumours.

Papillomata, warts and villous tumours.—Papilloma resemble in structure the papillæ of the skin and the villous processes of mucous membranes. They have a framework of connective tissue covered by epithelium. The papillæ are branched and higher than normal, and the epithelium is thicker. On mucous membranes they are broad-based or sessile on the one hand, or pedunculated and much branched on the other, forming the villous tumours. The connective tissue surrounds one or more blood-vessels, a branch from which passes into each process; the epithelium is sharply separated from the connective tissue, into which it does not penetrate. They are liable to ulcerate and bleed, and may, in older people especially, be gradually transformed into carcinomata by the epithelium growing downwards into the connective tissue.

Clinical varieties—Warts.—There is a difficulty in drawing a line of distinction between warts which are new growths and warts of inflammatory origin. Ichthyotic warts are met with in childhood, congenital in origin; senile warts, *verruca senilis*, arise in old people. They consist of papillæ, much increased in height, covered by epithelium, of which the corneous layers have become of marked thickness. The soft, fleshy, congenital warts are covered with skin under which are masses of epithelioid or endothelial cells (see *Lymphangioma hypertrophicum*). Papillomas of mucous membranes are broad-based or sessile, and generally arise in the larynx, nose, kidney, rectum and bladder. In the rectum and bladder, in the dilated ducts of the breast, and in the interior of cysts (*q.v.*), they are generally pedunculated. They may then form delicate branching growths, called, from their resemblance to the villi of the chorion, villous tumours. In other cases they may form a lobulated mass like a cauliflower, as when growing from the penis or ovary. The pedicle in such (Fig. 47) consists of submucous connective tissue in the middle of which runs a blood-vessel, covered by normal epithelium columnar or stratified.

But many forms of warts are not really tumours, but the result of inflammation. Infectious papillomata are common on the hands of children, especially when not in good health, and are easily inoculable. Condylomata or mucous tubercles are flat elevations of epithelium and connective tissue, infiltrated by inflammatory cells. They rapidly develop in the course of secondary syphilis at the junctions of skin and mucous membrane about the genitals, anus,

and mouth. Instead of "mucous tubercles," the term "mucous patches" should be used. Their mucous secretion is a ready source of syphilitic infection, not necessarily of condylomata. Gonorrhœal warts are inflammatory hypertrophies of simple and compound papillæ occurring on the skin and margin of the mucous membrane of the genitals. They differ from condylomata in being pointed. They are a source both of gonorrhœal infection and of similar warts. Inflammatory warts of a like kind occur on the penis of dogs and in the vagina of bitches, being transmitted by direct inoculation. These infective papillomata of inflammatory origin spontaneously

FIG. 47.—Papilloma. Photograph of a vertical section through a papilloma of the rectum. The peduncle has a stem of delicate submucous connective tissue, in which the blood-vessels run, which divides into numerous branches, all covered by columnar-celled epithelium, and passing over without any distinct line of separation into the normal mucous membrane as seen to the left.

disappear, but this may be hastened by astringent applications, or caustic, or the cautery.

Papillomata resembling true papillomata are produced in the gall-bladder, kidneys and bladder by stones or by a foreign body, and ultimately may become malignant.

Treatment.—True papillomata require in all cases to be completely removed by cutting widely through the skin or mucous membrane and connective tissue around and below the pedicle. It is not enough to cut through the pedicle or even to shave it off level, for recurrence follows. The central artery may require a ligature. In this way all doubtful cases, otherwise tending to cancer, may be cured.

Adenomata or glandular tumours.—*Adenomata* form circumscribed, mainly encapsuled, growths in the skin, mucous membranes or glands, without infiltrating or forming metastases. Therefore, they are regarded as benign tumours. They are characterised by the new formation of glands in connection with pre-existing gland tissue, from which they differ more or less in appearance, in that they do not form true ducts, or secrete. They are divided, according to the glands in which they grow, into the *acinous* variety, consisting of groups of acini, lined with spheroidal epithelium communicating with one another, and into the *tubular* variety, in which the epithelium

Fig. 48.—Fibro-adenoma. Photograph of a section through an enlarged prostate. Alveoli, which are distended owing to obstruction of ducts, are surrounded by an increased amount of inter-alveolar fibrous tissue.

is more columnar. They possess a connective-tissue stroma, partly of pre-existing, partly of newly formed material.

Adenomata arise sometimes in normal, sometimes in malformed glands, sometimes in glands previously diseased by inflammation, a cirrhotic liver, a granular kidney, an ovary with scars; sometimes they are derived from fœtal remnants. The origin of adenoma in previously inflamed glands makes it difficult to sharply distinguish adenomata from hypertrophy and from regeneration.

Clinical varieties.—*Tubular adenomas* occur in mucous membranes and tubular glands, such as those of the intestine and uterus; also in the ducts of the breast, liver and kidneys, or ovary. They are characterised by the formation of simple and branched cylindrical tubes lined with cylindrical or cubical epithelium, forming tumours varying in size from a pea to a fist. By projecting above the surface they may appear as papillary growths and polypi.

Acinous or *alveolar* adenomas arise in glands, such as the breast, thyroid and sebaceous glands. A number of grape-like acini connected by a duct-like channel. The *papilliferous* adenoma formed by papillomatous growths projecting into the alveolar aces, or even quite filling them, or distending them by intra-cystic owths. If the connective-tissue stroma is well developed, the mour may be hard and form a fibro-adenoma, *e.g.*, around the naliculi in the breast, or it may be soft and vascular, *e.g.*, in the yroid gland. The connective tissue may undergo myxomatous generation, *myxo-adenoma*, or cysts may develop in it, *cysto-adenoma* ee *Cysts*, p. 157).

Adenomas cannot be sharply differentiated from carcinomas. The ancerous character of an adenomatous tumour is recognised by arked epithelial proliferation and infiltration. Thus, in the ntestine a tubular growth of a single layer of columnar epithelium, hen it infiltrates the connective tissue and muscular wall, is cognised as carcinoma. But there may be marked epithelial roliferation in the case of adenomas of the breast and uterus, ithout for some time penetration of the basement membrane and nfiltration of the connective tissue.

Malignant Epithelial Tumours.

Carcinomata.—Carcinomas are composed of epithelial cells surrounded by a connective tissue arranged more or less like alveoli, and are characterised by infiltrating indefinitely beyond the tissue in which they originate and by forming metastatic growths in distant organs. The alveolar arrangement shows some resemblances to the normal structure in which the growth arises, and the cells of the cancer may still contain secreted materials, yet the arrangement of the alveoli is atypical, *e.g.*, no ducts are formed, the epithelial cells are out of place, and there is no regular secretion. A mammary carcinoma shows resemblance to the normal breast structure, and a milky juice can be squeezed out from the tumour. Gastric and pancreatic carcinomas have resemblances to the normal structure of the stomach and pancreas respectively, and their cells may contain peptic and tryptic ferments, which prove active in an artificial digestion mixture. Carcinoma of the thyroid resembles the normal gland, and cachexia strumipriva having supervened upon the excision of the whole gland, the development of metastatic growths with the structure of the primary tumour has been followed by the disappearance of the cachexia.

General origin.—Carcinomata arise from the proliferation of pre-existing epithelium in connection with: 1. Skin, mucous membranes, and glands, apparently unaltered before the commencement of the carcinoma; 2. Skin, mucous membrane, and glands, previously altered by inflammation; 3. Previously-existing benign growths,

adenomas, papillomas, cysts; 4. Remnants of fœtal structures and misplaced epithelial masses. 5. Epithelial cells of the chorion and placenta.

The epithelial cells are descended from epiderm or epiblast, and hypoderm or hypoblast, but also from mesoderm in the case of the ovary, uterus and tubes, kidney, bladder, prostate and suprarenal capsule.

General development.—The epithelium commences to proliferate so as to form more layers than normal, but this may happen without the disease being malignant, as in the case of a papilloma or adenoma

FIG. 49.—Carcinoma developing from an adenoma. Photograph of a section through a cancer of the breast, which had developed from an adenoma. Remains of the breast tissue is seen, from which rapidly-dividing spheroidal cells have invaded the connective-tissue stroma.

or even of chronic inflammation. The characteristic commencement of carcinoma is the breaking through the wall of the alveolus or duct, or the basement membrane of the skin or mucous membrane, and the *invasion by the epithelial cells of the surrounding and underlying connective tissue.* These epithelial cells, now out of place in the connective tissue (Fig. 49), continue to proliferate, forming spherical or oval, or tubular or flask-shaped masses. They may be arranged around a cavity like an alveolus, or as if lining a tube, or in concentric layers to form cell-nests. They soon break into the lymphatic spaces, where they may form thrombi; grow along the connective spaces (Fig. 50), or they may be carried, as emboli, to the neighbouring lymphatic gland. The epithelial cells develop, following in their type the epithelium from which they

spring. Around the growing margin of the epithelial mass is set up inflammation; a small-celled infiltration precedes the growth, some cells being leucocytes, others fibroblasts, from which a variable amount of connective-tissue stroma is developed, enclosing the epithelial cells. Blood-vessels run in this stroma, and are numerous in the rapidly-growing tumours. Where the fibrous stroma is in excess they are few, and may become obliterated later on, and so lead to degeneration. Meanwhile the invaded tissue disappears before the epithelial growth and the surrounding inflammatory zone, none of it remaining; even the more resisting tissues, such as bone and cartilage, are rapidly eroded.

A naked-eye section of a carcinoma gives an appearance varying

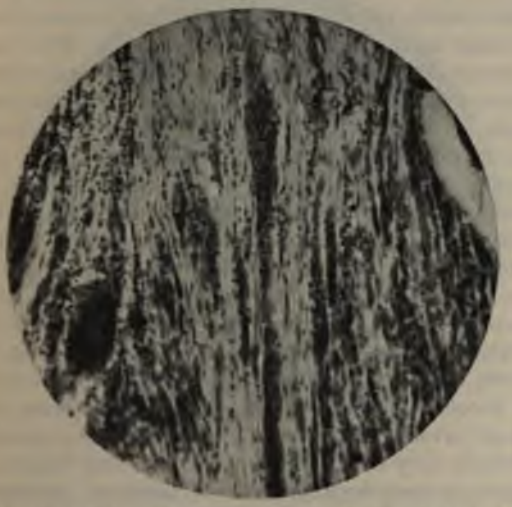

FIG. 58.—Spheroidal-celled carcinoma, spreading by the lymphatics. Photograph of a section through the pectoralis aponeurosis midway between the breast, enlarged by carcinoma, and the axilla. Rows of rapidly-dividing spheroidal cells fill the lymph spaces.

between a densely-fibrous non-vascular growth and a soft vascular brain-like or medullary structure. From the surface of the section can be scraped a juice showing epithelial cells more or less degenerating. No sharp line of demarcation or capsule limits the tumour from the surrounding healthy tissue, nor is the boundary a regularly curved outline. The growth must be considered to extend for at least a quarter to half an inch into the apparently quite healthy tissues, and often much more.

When occurring on the surface of the skin or mucous membrane, the growth may present a spongy, papillary, polypoid, cauliflower-like appearance, but is yet combined with infiltration of the tissues around its base.

Degeneration.—Carcinomas of the skin and mucous surfaces, as those which reach the surface from the depth, ulcerate and fungate whilst suppuration extends into the deeper part. Rapid destruction goes on, with hæmorrhages, and the patient suffers from septic absorption. Both clinically and microscopically the inflammation may obscure the signs of the new growth and render the diagnosis difficult.

Fibrous degeneration, and even calcification, may occur in slow-growing or scirrhous cancers. In other cases, owing to the diminution of the blood-supply, a myxomatous, colloid, hyalin or gelatiniform degeneration occurs. The epithelial cells swell up from the formation of mucin or a mucin-like body, become vacuolated, or replaced by a glistening, semi-translucent, jelly-like or semi-fluid substance, whitish or brownish—hence the term colloid; but the substance is not apparently the same as the thyroid-gland secretion. This fluid presses the cells to one side, or only their nuclei appear, or a reticular formation develops. Cysts form, especially in the case of the ovary. This myxomatous or colloid degeneration is common in cancers of the stomach and intestinal tract, omentum and ovary, and occasionally in the breast.

Carcinoma in lymphatic glands.—Epithelial cells broken off from the primary cancer reach the neighbouring lymphatic glands, and being there arrested in the meshes of the reticulum, begin to rapidly proliferate, so that from one or several foci the whole gland is replaced by carcinoma (Fig. 51). Then the capsule is broken through, and there is extension of the growth into the neighbouring connective tissue, where, meeting similar processes from neighbouring glands, the whole becomes matted together into a diffuse mass, which later extends and invades neighbouring important structures, such as large vessels, or may reach the skin, ulcerate and fungate.

Metastases or secondary growths.—Tumours corresponding in structure and general characters with the primary growth appear in internal organs such as the lungs, liver, bones or on distant points of the skin, less commonly of mucous membrane. They may appear singly, but generally are multiple. It has been shown experimentally that, by crushing, cells such as those of the liver, bone-marrow and placenta may get into the circulation and be carried to some distant part. Carcinomas are the most common cause of metastasis. This takes place especially through the lymphatics, by way of the neighbouring lymphatic glands; but carcinomas, especially the more malignant sorts, also break into veins, and so reach the circulation directly. Whilst sometimes the growth extends by direct continuity, yet in most cases the epithelial cells, like emboli, pass through long distances of the lymphatic circulation, the thoracic duct, the pulmonary circulation, and far along the arteries, before being arrested. The cause of the arrest which gives rise to the metastatic growth is unknown. Generally, the secondary tumour grows from a centre by

extension in all directions, but occasionally may be more or less a diffuse infiltration.

General course of carcinoma.—The patient may suffer little or nothing at all in the early stages of a primary growth. This is so often the case that it presents the greatest obstacle to early and timely removal, in that the growth is unnoticed until too late for a cure. If on the surface, the tumour may be noticed by chance or by a slight pain. The more deep-seated the tumour the longer may it escape recognition. When some special symptom is set up, such as obstruction, in carcinoma of the alimentary canal, the growth has been without doubt present for many months, and is often too

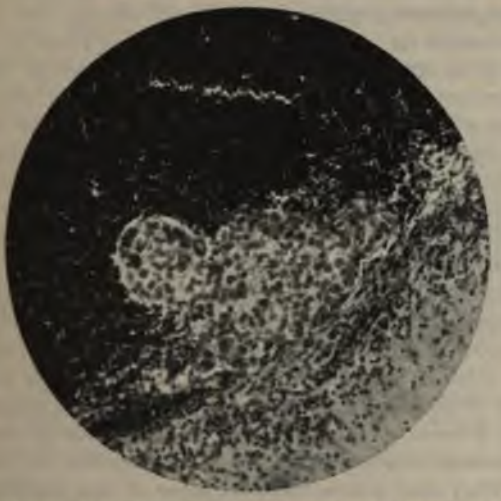

FIG. 51.—Carcinoma developing in a lymphatic gland. Photograph of a section through an axillary gland removed with a cancer of the breast. Rapidly-dividing spheroidal cells fill the lymph sinus, and are beginning to invade the cortex of the lymphatic gland, also its capsule, which is infiltrated by leucocytes.

extensive for removal. Even when attention has been drawn to the part, *e.g.*, by chronic inflammation in the case of the tongue or cervix uteri, it is difficult for some time to be sure that carcinoma has supervened.

Whilst it is generally the case that carcinoma causes no marked symptoms until either metastases form or ulceration and septic absorption occur, yet the primary growth, the extension in lymphatic glands, or the metastatic growth, may give rise to some complication, such as intestinal, portal, biliary, or urinary obstruction, to spontaneous fractures of bones, to hæmorrhages on surfaces, cutaneous or mucous, or into serous cavities; or to pain either by involving some special nerve or by general infiltration in a sensitive part. As soon as septic absorption occurs there commences the rapid impo[illegible] of

health known as cancerous cachexia, *i.e.*, septic anæmia with rapid wasting sets in. The skin becomes sallow, has an earthy look, the face is careworn and anxious, the body emaciates, the strength fails and the patient dies exhausted.

Anomalies in the clinical course of malignant disease.—Malignant disease usually pursues a steady course towards a fatal issue; exceptionally, however, it behaves in quite an anomalous manner. Thus it may spontaneously disappear by a process of atrophy and absorption, leaving behind merely inflammatory scar-tissue, or it may become quiescent or shrink for a time, and after a while begin to grow again. Further, after the removal of the primary disease, although it is the rule if it recur for it to do so quickly either in the scar, neighbouring glands, or internal organs, yet occasionally there is no return for long periods, such as nine years in the larynx, and fifteen to thirty in the breast. Hence, the dictum that if there is no recurrence after three years a cure may be claimed, must be accepted with reservation. Again, although it is usual for a recurrent growth to have the same structure and run a similar course as that of the primary disease, at times it may have a different structure, or may be merely of the nature of an inflammatory new formation; and even when the microscope has shown it to have a malignant character, it may yet suddenly cease to grow or undergo atrophy and disappear. Nor must it be forgotten that clinical observations are sometimes at variance with microscopic examinations; where this occurs the former are the more trustworthy, owing to the number of fallacies connected with the latter. Such anomalies in the clinical course justify to a certain extent a surgeon in not committing himself too absolutely to the diagnosis of cancer in the patient's hearing, although they are too infrequent to influence his practice. They may also account for some of the successes claimed for the so-called cancer cures.

Varieties of carcinomata.—The carcinomata are divided into four classes, in accordance with the shape of the epithelial cells and their structural arrangement:—

1, Spheroidal-celled or acinous carcinomata; 2, Columnar-celled or tubular carcinomata; 3, Squamous-celled carcinomata, in relation to which the term epithelioma is more particularly used; and, 4, Rodent ulcer.

1. **Spheroidal-celled or acinous carcinomata.**—The epithelial cells are spheroidal in shape, growing in connection with racemose glands, the character of the epithelial cells and the acinous arrangement characteristic of the particular gland being retained by the primary and secondary growths, although in an atypical fashion. They vary pathologically according to the amount of fibrous stroma, and clinically according to the rate of their course.

(*a*) *The scirrhous* or *hard spheroidal-celled carcinomata* exhibit a large amount of fibrous stroma (Fig. 52), which may be in such

the nipple is retracted in scirrhus of the breast. On section
ue creaks under the knife, and the section appears concave.
umours generally grow slowly, so that the primary growth
small, and in the extreme form of atrophic scirrhus may
almost stationary or even get less by fatty degeneration.
slowness of development of the primary growth does not
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Lymphatic glands, although not
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ed of the new growth covered by
tion cells, giving rise to a few pus corpuscles and a sanious,
charge.

Fig 52.—Hard spheroidal-celled or scirrhous carcinoma.

The encephaloid, medullary, or soft spheroidal-celled carcino-
Fig. 53) show a scanty amount of very vascular fibrous
; the cells in the large alveolar spaces are in several layers.
margin the epithelial cells are proliferating rapidly and
ng into the surrounding tissue, which disappears before the
, whilst there is no marked inflammatory zone. The tumours
, elastic, semi-fluctuating; the surface of a section appears
or creamy-white blotched with blood; hence the name
loid, brain-like or *medullary*, marrow-like. Towards the
the substance is liable to fatty degeneration, so that it

Between the scirrhous or hard variety and the encephaloid or soft, there is no hard-and-fast line to be drawn in practice, and the characters of individual cases make it often impossible to classify the tumour in one category or the other. In the case of the breast definite instances of scirrhous or encephaloid cancer are common; not so in other parts. Even in the breast a primary scirrhus may give rise to soft, rapidly-growing metastases.

2. **Columnar-celled or tubular carcinomata.**—The epithelial cells are columnar or cylindrical, growing from columnar epithelium, tubular glands, and the ducts of racemose glands (Fig. 54). They

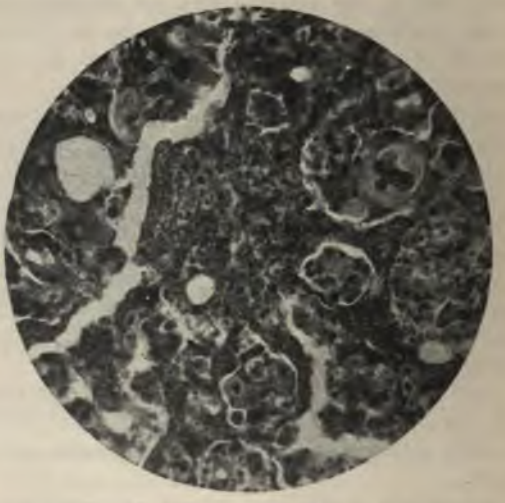

FIG. 53.—Soft spheroidal-celled carcinoma. Photograph of a section through rapidly-growing cancer of the breast. There is but little fibrous stroma. The cells are swollen from commencing colloid degeneration, some have degenerated, and the nuclei are agglomerated. Other cells show irregular divisions of nuclei, appearances which have sometimes been supposed to indicate parasites.

consist of irregular tubes lined with columnar epithelium. In the more slowly growing there is a regularly-arranged, single row of distinctly columnar cells enclosing a central lumen; in the more rapidly growing, several layers of more cubical, or almost spheroidal, cells nearly or quite fill the central space. Around the epithelial cells is an alveolar arrangement of fibrous tissue, which may be very small in amount in the soft varieties, or marked in amount as in the annular carcinomas of the intestinal tract, or there is diffuse infiltration and thickening, as in the wall of the stomach which has been compared to that of a leathern bottle. Papillary or cauliflower-like outgrowths are met with in the villous tumours of the rectum and bladder, and papillary outgrowths into dilated ducts are seen in

duct cancer of the breast. These growths rapidly break down, giving rise to hæmorrhages and a foul discharge.

On the whole, the primary growth remains a local disease longer than the spheroidal-celled acinous carcinoma, the lymphatic glands are not so soon infected, and metastases form later, and are fewer in number. Thus duct cancer of the breast is a much more favourable, although a rarer, growth than scirrhus.

Cancers of the rectum, intestine, and stomach are also favourable, and lend themselves to removal in older patients, but in patients below forty they are very malignant. Extreme malignancy nearly

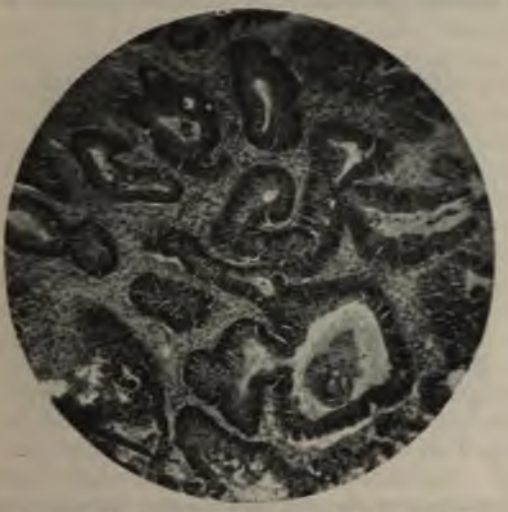

Fig. 54.—Columnar-celled, or cylindrical or tubular carcinoma. Photograph through a section of carcinoma of the rectum. One or more rows of columnar cells enclose a lumen and form tubular masses surrounded by an alveolar arrangement of fibrous-tissue stroma.

always marks the course of a cancer of the pancreas. Complications in connection with the primary growth are frequent—pyloric, biliary, intestinal and pancreatic obstruction, ulceration, and hæmorrhage from the bladder and rectum—and these along with septic infection are frequently the cause of death, before the lymphatic glands are markedly infected or metastases have developed. Occasionally a secondary growth comes into prominence, whilst the primary growth escapes notice, so that a malignant mass, *e.g.*, in a bone, is found to present the peculiar structure of an intestinal carcinoma.

Deciduoma.—An hydatid mole arises in the uterus from myxomatous degeneration of the chorionic or placental villi, causing them to swell up into small cystic bodies united by delicate connective tissue like

a mass of grapes. The villi show, in addition, a certain amount of proliferation. These ectodermal cells of the chorionic and placental villi, especially the cells of the syncytium in the neighbourhood of the attachment to the uterine wall, may proliferate and grow into the blood spaces forming thrombi, invade and replace the entire wall by a carcinomatous new growth, and then extend and give rise to metastases.

3. **Squamous-celled carcinomata, especially called epithelio-mata.**—These are characterised by being composed of cells resembling stratified epithelium, and grow from the skin and mucous membranes covered by stratified squamous epithelium, and from similar epithelium lining dermoid cysts and other epithelial remnants, and are more

Fig. 55.—The growing edge of a squamous-celled carcinoma (epithelioma). (From Bowlby's Pathology.)

especially common in the neighbourhood of the junctions of skin and mucous membrane, as the result of chronic irritation. The cells of the rete Malpighii, especially those lying between the papillæ, grow downwards as flasked-shaped processes into the underlying connective tissue (Fig. 55). In chronic irritation the papillæ are often much elongated, and the interpapillary processes descend further, but there is no actual invasion of the connective tissue. In squamous-celled carcinoma the flask-shape down-growths branch and give off isolated clumps and masses of epithelial cells lying surrounded by connective tissue, or the masses of epithelial cells follow the lymphatic channels and become moulded into tubular masses. From these other clumps are given off, until there are numerous solid islands composed of squamous epithelium surrounded by connective tissue, so that in this form the alveolar arrangement seen in spheroidal-cell carcinoma is much less marked. The down-growing columns and

the several islands are surrounded by a connective-tissue stroma at first normal, then replaced by a small-celled infiltration, some cells consisting of leucocytes, others of fibroblasts, from which the new fibrous tissue arises.

Epithelial cell-nests.—There are found, both in the epithelial down-growths and in the epithelial islets and tubular masses developing beneath the epithelium, collections of cells arranged concentrically, like the layers of an onion, or like the balls or boxes, one within another, made by the Chinese. An excessive formation of corneous cells takes place towards the centre of a sphere, instead of as usual towards a surface. Thus the cells nearest the centre are the most scale-like and compressed, the outer ones polyhedral or cubical, and the most external of all cylindrical, like the cells of the rete Malpighii. The polyhedral or cubical cells show granules of keratin like the stratum granulosum; the scale-like cells result from a further kerato-hyalin change of the albumen, causing the cells to stain deeply with a ground stain like fuchsin, whilst the logwood staining of the nuclei is lessened. The centre of these *epithelial nests* or *pearls* may come to consist of a glistening, concentrically striated, or homogeneous mass, devoid of nuclei, of a horny character. These cell-nests, or horny epithelial pearls, are not, however, necessarily found in squamous-celled carcinoma, and similar bodies may be seen in other conditions, *e.g.*, in connection with normal skin, in stratified epithelium of mucous membranes, in the tonsils, and non-malignant scars, and even in papillomas, but then always in direct connection with the surface epithelium. From this it follows, that it is not essential for cell-nests to be found in scrapings or small pieces in order to diagnose epithelioma, and conversely, the finding of a cell-nest does not prove that squamous-celled carcinoma is developing in the tissue examined.

Cholesteatomatous or pearl tumours are characterised by glistening white pearl-like masses consisting of epithelial scales, concentrically arranged, and often containing cholesterin, and are chiefly found in connection with the middle ear. They arise either out of stratified epithelial cells, displaced there during development, or more generally by an invasion of the middle ear from the auditory meatus, through a perforation in the drum, as a result of chronic inflammation.

Besides growing downwards, a squamous-celled carcinoma also proliferates on the surface with the formation of a papillated or warty surface; or it may grow from an already existing papilloma, by the cells of the latter rapidly proliferating to form several layers, and then growing downwards into the connective tissue beneath. The surface of an epithelioma quickly ulcerates and breaks down, forming an ulcer covered by granulation tissue, but its base and margins are composed of carcinoma.

In chronic inflammation of an epithelial surface there may be

excessive thickening of the epithelium, *e.g.*, leucokeratosis or leucoplakia of the tongue, but all the changes for a time go on above the connective tissue, which is only infiltrated by leucocytes. The papillæ may be elongated upwards and downwards, but the commencement of the malignant change is marked by the down-growth of epithelial columns, which branch in the sub-epithelial tissues.

Clinical course.—A squamous-celled carcinoma may commence as a warty tubercle, which then becomes an ulcer with raised, everted, sinuous, indurated edges, and a hard, warty irregular base, whilst the tissue around is more resistant, and the lymphatic glands become hard and enlarge. At another time it begins by the induration of the base and edges of a chronic ulcer, which then become everted, and the discharges more profuse and foul. A long-existing crack or fissure, or the granulations round the orifice of an old-standing sinus, may begin to fungate, or a puckered scar becomes red, indurated, then ulcerated. Unless an epithelioma is removed early, an infection of the lymphatic glands, corresponding to the part, ensues, whilst there is less tendency than in spheroidal-cell carcinoma for the cells to be arrested and form thrombi in the lymphatics. Indeed, it has been considered that there is a distinct difference in this respect, that the squamous cells pass like an embolus along the lymphatics only to be arrested in the gland, so that the part between the primary growth and the enlarged gland may be considered to be free from disease. The epitheliomatous masses begin in the lymphatic glands at one or more points, until the whole gland is occupied, and an extension follows. The mass soon softens and breaks down, probably favoured by the septic absorption from the ulcerating primary growth. Dissemination but very rarely occurs in internal organs or in the bones, then only at a late date.

Death usually occurs from complications connected with the primary growth or the enlarged glands, such as anæmia from hæmorrhage, septicæmia from ulceration, or involvement of neighbouring important structures.

Squamous-celled carcinomas are met with on the skin, lips, mouth, tongue, pharynx, œsophagus, anus, cervix uteri, vagina, vulva, penis. An exceedingly slow-growing type of epithelioma occurs on the skin of the scrotum, and one nearly as slow on the lip. Generally they arise in old age, and affect men far more than women. Should they appear in young adults, *e.g.*, on the tongue or in the scar of a burn, they run an especially rapid course.

4. **Rodent ulcer.**—This is an anomalous form of tumour arising in the deeper layers of the skin, especially the skin of the face near the inner canthus of the eye, but also occasionally elsewhere on the face, scalp, neck, trunk, or limbs. It is peculiar in its structure, showing cells generally resembling those of the sebaceous glands,

arranged somewhat like a squamous-celled carcinoma, but without a, or only showing an occasional, cell-nest, and continuing to ulcerate and extend, but with remarkable slowness, spread over many years. Moreover, the lymphatic glands remain free, and there are no metastases, even after years. It is readily cured by excision, and, more curious still, under the influence of light-rays tends to heal and disappear. The cells of which it is composed are smaller and rounder than those of squamous-celled cancer; flask-shaped, much-branched processes grow downwards into the connective tissue from the sebaceous glands, and are surrounded by an inflammatory zone. Cell-nests are either absent or ill-formed, and not horny, whilst generally the cells resemble those of sebaceous glands. In rarer cases they appear

Fig. 56.—Early stage of rodent ulcer before it has pierced the epidermis. (From a drawing by the late Prof. Kanthack.)

to have been derived from sweat-glands, or from the deeper layers of the stratified epithelium of the skin or the hair-follicles; but it is doubtful whether such growths are not really epitheliomas. The growth is at first covered by normal skin, beneath which it feels like a nodule, and it may thus remain stationary for a long while; then ulceration commences. There is a single ulcer with edges sinuous and a little raised, yet not markedly indurated or everted; the base is slightly depressed, glazed, void of granulations, of a pale colour. When small, the ulcer is covered by a scab, detached at intervals. The skin around is healthy. Some attempt at spontaneous cicatrisation often appears or follows scraping, and this scarring is rendered definite by the light-treatment. If not so treated, and not excised, extension goes slowly on during years, to muscle and bone, which are eroded and destroyed. The eye, the skull, the face,

are perforated, and the brain exposed, leaving a large chasm. Death occurs from septic exhaustion, hæmorrhages, meningitis.

Diagnosis.—Rodent ulcer is usually recognised by its occurrence on the face, just below the inner canthus, in an old person. Less often it is seen elsewhere on the face, rarely in other parts, the scalp, arms, breast, and in young patients. Then its slow development and clinical characters, also the microscopic examination of a piece removed aids in diagnosis. The light-treatment causes rapid and permanent scarring in a true rodent ulcer, whilst a chronic epithelioma becomes more vascular, fungates and grows more quickly.

Treatment of carcinoma.—In the absence of any exact knowledge as to the origin of cancer, or of any means of arresting its development, *excision* remains the one method for obtaining a cure, in spite of the deformities occasioned thereby. Only in the case of rodent ulcer has the light-treatment been successful, yet this is of great importance as showing the possibility of an inflammatory sclerosis overcoming epithelial cells. Unfortunately, it is notorious that inflammation usually excites malignant epithelial cells to more rapid development, and that the reduction of inflammatory complications is the most important of merely palliative measures.

To cure, the growth must be removed at the earliest possible moment, as soon as the diagnosis can be made. This is often completed or confirmed by the microscopic examination of a piece of the growth removed as a preliminary, or as an introduction to the operation itself, a section being rapidly examined, whilst the surgeon waits. The complete removal of the primary growth is required, the real margin of which must be assumed to extend at least for a quarter to one-third of an inch, or more, into the surrounding tissues, beyond the apparent margin. Hence the knife must skirt the growth at least half an inch, and in very malignant cases further still, outside the apparent margin. If not, growth will recur in the scar.

Generally excision should be done with the knife, aided sometimes by scissors, very rarely by the cautery. Neither blunt methods, nor the écraseur, nor any method involving tearing should ever be employed. Moreover, it is necessary to excise not only the lymphatic glands corresponding to the affected area but also the lymphatics running between the primary growth and the glands. Particularly is this the case in spheroidal-celled carcinoma. The chief example of this is that of mammary cancer. It is not necessary for any disease in these glands to be observed clinically, although infiltration will be generally met with upon a thorough microscopical examination. Perhaps in the case of squamous-celled and columnar-celled carcinoma, it may be sufficient in very early cases to remove the primary growth very widely; in the later and more malignant cases, also the corresponding lymphatic glands whenever this is practicable, as in the case of the tongue. It has been conjectured that such cancers are not so likely to form malignant thrombi in the lymphatics, as

in the case of spheroidal-celled cancers, so that perhaps the tissue enclosing the lymphatics intervening between the primary growth and the lymphatic glands may be spared.

When the growth reappears within a year or so of the operation, it must be concluded that some of the disease was left behind, either the primary growth or the lymphatic glands not having been removed widely enough. Recurrence of a growth in the scar at a much later date, many years, even as many as thirty years, after the primary excision is difficult to explain, except on the assumption that it is a fresh appearance of carcinoma, from a renewed activity of the causes which produced it in the first instance, favoured by the presence of the scar. Such an occurrence cannot be prevented by any excision, however wide.

Generally speaking, a patient is benefited only when the disease can be completely removed, the primary growth and its extension to the lymphatic glands, so that at the worst the patient will be relieved for a year or more. An incomplete removal rarely benefits him, and often increases his sufferings.

In doubtful cases the operation should be begun with caution in order to explore the extent of the disease. The surgeon must decide that removal cannot be done before dangerous hæmorrhage or shock has been occasioned, or structures interfered with not hitherto involved in the disease.

Palliative treatment of cancer where the growth cannot be completely removed.—The excision of a fungating mass is rarely of benefit, for the wound left is infiltrated by cancer. Generally it is best to try to render the fungating growth less foul; only when, as in the case of the tongue, cervix uteri, etc., the primary growth is limited, mobile, and surrounded by fairly healthy tissue, may its removal occasionally be undertaken.

The same remark applies to lymphatic glands; but if these have become infected by suppuration and are breaking down, the septic absorption may be rendered less by incising or partly removing these masses and treating the cavities as foul abscesses.

Special symptoms caused by the primary growth when it involves some important structure call for relief by operation, gastrostomy for œsophageal cancer, tracheotomy for laryngeal obstruction, colostomy (colotomy) for intestinal obstruction, drainage of the bladder, etc. Yet these are operations not to be systematically used, but only when the patient's life will otherwise be materially shortened and rendered more miserable.

The great palliative measure is the prevention or limitation of septic complications by which pain is indefinitely increased, the discharges rendered foul, breaking down of the growth and hæmorrhages favoured, and the cancerous cachexia and final exhaustion of the patient much hastened by septic absorption. This consists in the free use of suitable antiseptics for foul ulceration and suppuration.

The great medicinal remedies are opium and morphine, which, when the disease is obviously running a fatal course, may be gradually and indefinitely increased, so long as no bad symptoms arise. In addition, iodide of potassium will often give relief for a time by diminishing congestion. Acute crises of pain and nervous excitement may subside after a dose of phenacetin, combined or not with caffein.

For topical applications, besides the antiseptic measures, iodoform, or orthoform in powder, opium combined with stramonium, or conium in ointment, or belladonna may prove satisfactory. *Vomiting* in abdominal cancer may be relieved by temporary rectal feeding, by injections of morphine and atropin, by lozenges of morphine or cocain, also by oxalate of cerium.

Caustics should be discarded. If it is wished to get rid of a fungating mass, this should be done by the actual cautery under an anæsthetic, followed by opiates.

Thyroidin has been administered and a check or temporary arrest in the growth reported. Short of causing thyroidism it does no harm, and should not be pushed beyond.

Bilateral oöphorectomy has sometimes been followed by a softening, partial disappearance, or even an arrest of the growth for six months or longer, in cases of recurrent mammary cancer, and in that disease only. It is purely an empirical measure, no theory explaining it. Those who have lost their ovaries appear just as ready subjects for cancer, and the operation has been quite, if not more successful in patients already past the climacteric. Some of the cases may have been instances of the occasional anomalous course of malignant disease (p. 144). Yet no particular harm seems to follow the operation when properly done, and it may well be tried if the patient wishes it. But the operation is of no value in any other than mammary carcinoma, and experiments on these lines, such as castration in men, may be emphatically condemned.

Coley's fluid contains toxins derived from the streptococcus of erysipelas mixed with those of the bacillus prodigiosus, and has been injected into and around inoperable sarcomas. It is an experiment not free from the danger of severe or even fatal septic intoxication. In some 15 per cent. of cases, especially inoperable cases of spindle-celled sarcoma, fatty degeneration and permanent shrinkage or sloughing has been reported.

Cancer extracts of various kinds have been tried. The cancroin of Adamkiewicz is an aqueous solution of citrate of neurin, which, when injected into or around the growth, causes great pain, without in most cases any benefit.

Light and electrical treatment are now being much used.

Electrolysis has not hitherto had any success, except in Apostoli's treatment of fibroids. Electrical currents of high tension and frequency are under trial.

The x rays have been decidedly successful in the treatment of rodent ulcer. In most other superficial cases, primary epithelioma of the skin or recurrence in the scar of the breast, no good is done by the application. Yet improvement has been reported in the practice of some; so that it may be tried, being stopped should the rate of growth seem to increase. As to the use of the *x* rays for deep-seated cancer, no success appears to have been obtained.

The Finsen light does not appear to be more efficacious than the *x* rays.

(C.) Teratoid Tumours composed of both Connective Tissue and Epithelial Elements.

Teratomata.—Under the title of *teratomas* or *teratoid tumours* are placed rare forms of new growth, composed of various tissues, both connective tissue and epithelial, as if derived from all three layers of the embryo; of tissues misplaced (*heterotopic*), or untimely (*heterochronic*), as regards the period of development; of tissue similar to bone, hair, teeth, or that of a dermoid cyst; tumours, both solid and cystic; of a mixed structure, similar to that described under Endothelioma; or, finally, various portions of the viscera, etc., of a suppressed fœtus or rudimentary twin.

The misplacement of cells, a heterotopia or development of tissue abnormal to the part, may be explained as follows:—

(*a*) A cell or group of cells remains undifferentiated, retaining the property of forming both epithelial and connective-tissue elements. Such cell or cells may then go on to form a mixed solid or cystic tumour, a rudimentary or considerably developed monster.

(*b*) Embryonic cells belonging to another part are at an early period included, *e.g.*, cells of the epidermis, in the skin, so as to form a simple dermoid cyst, but this is insufficient to explain the complicated dermoid cysts of the ovary.

(*c*) At a later stage tissue may be displaced, *e.g.*, when a meningocele recedes and draws fat and muscle into the spinal canal.

Teratomata, complicated solid and cystic tumours, are most common in connection with the ovary, in the testis, in the sacro-coccygeal region in connection, it is presumed, with the canalis neuro-entericus, also at the upper end of the alimentary canal about the hypophysis, causing polypoid tumours in the naso-pharynx. To this class also belong some abdominal tumours, kidney tumours connected with the Wolffian body and ducts, and mediastinal tumours connected with the thymus.

The ovary may be occupied by a dermoid cyst (see *Ovary*), the wall of which is comparatively simple in structure, viz., composed of stratified epithelium and dermis, with sebaceous glands, hair-follicles, also subcutaneous fat and sweat-glands. But at points in its wall may also be found cysts and tubes lined with ciliated epithelium,

columnar epithelium, thyroid gland tissues (hypoderm), bone and cartilage, muscle, even heart muscle (mesoderm), teeth, brain material, nerves, ganglion cells, mucous glands, choroidal pigment (epiderm). Mixed with this may be carcinomatous tissue, acinous or epitheliomatous, or sarcomatous tissue, with myxomatous degeneration of epithelial tissues to form cysts. Rarer still, these tissues, more confusingly mingled, may compose a solid tumour of the ovary, as if an ovum had developed, but in the utmost disorder, so that the tumour has been called an *embryoma*. Some see in this parthenogenesis, the development of an unfertilised ovum, others a fertilised polar body, others an irregular segmentation of an ovum, one half a perfect blastomere, the other imperfect or imperfectly fertilised, yet capable of further irregular segmentation.

Teratomata of the testis are rarely of the complicated character mentioned above, but have been called multilocular cystic tumour, cystic adenoma, chondro-adenoma, chondro-sarcoma, adeno-myo-sarcoma, or simply cystic sarcoma or cystic carcinoma. Some of these tumours may be referred to the endotheliomata, others may be looked upon as new growths connected with the remains of the Wolffian body.

A more or less developed included fœtus may form an abdominal tumour, partly protrude from the abdominal or thoracic wall, or be loosely attached. Twins are born partly joined, and surgeons have been asked to divide them, when it may be found that the pleural or peritoneal cavities, the livers, the intestinal or urinary systems, are united.

CYSTS.

A cyst is a sac containing fluid, or semi-fluid, gelatinous or inspissated material. Under this term, cyst or cystic, are collected for practical purposes a number of conditions which defy pathological classification, having this in common, that one or more cavities exist. But the walls of cysts are of very various structure, the contained fluids are totally different in composition. Many cysts are not tumours at all, except in the loose sense of a swelling, but collections of fluid in cavities due to inflammatory causes. Some cysts are merely degenerating tumours, others tumours of new formation.

Cystic degeneration is mainly myxomatous or colloid, preceded by dropsical or œdematous swelling of cells and by fatty degeneration of connective tissue. Dropsical or œdematous swelling of cells is a change in the protoplasm by which serum is taken in. It occurs in inflammation, and is seen in both epithelial and connective-tissue cells, also in new growths such as carcinomas, the cell protoplasm and nucleus being distended by vacuoles, as a preliminary to the destruction of the cell. The microscopic appearances so produced form pitfalls for the unwary. Fatty degeneration makes tough and

resistant connective-tissue cells yield owing to the distension of the cells with fat globules and results from diminution of the blood supply. The fat globules may collect as in dermoid cysts, or crystallise into needles and cholesterin plates. Rupture of blood-vessels and blood extravasation readily occur.

Myxomatous degeneration.—Under normal conditions mucus is formed by the goblet cells of mucous membranes, and from the protoplasm of cells in mucous glands, with or without destruction of the cells, and by connective-tissue endothelial cells in the synovial membranes of joints, tendon sheaths, and bursæ. The jelly-like portion of the umbilical cord and the vitreous humour consist of mucus. The substance, mucin, contains nitrogen and sulphur, also a carbo-hydrate forming an animal gum. Nucleo-albumen has similar physical properties, being sticky and semi-fluid. It is obtained from cells largely consisting of nuclei, and is characterised by the amount of phosphorus it contains. In mucous catarrh there is an increased secretion of mucus with a myxomatous change in the pus cells. Epithelial cells in new growths, such as adenomata of the breast, ovarian tumours, and intestinal carcinomata, readily undergo a myxomatous degeneration. So also do the connective tissues, bone, cartilage, inflammatory growths, such as syphilitic gummata, and sarcomata. By this means a fluid collects containing mucin or allied substances, pseudo-mucin, with great liability to the giving way of blood-vessels and extravasation.

FIG. 57.—A sebaceous cyst divided into halves, and one half emptied of its contents. It is surrounded by a distinct capsule, and is situated in the skin proper superficial to the paniculus adiposus. (St. Bartholomew's Hospital Museum, No. 3364 *c*.)

Hyalin and colloid degeneration.—The secretion of the thyroid gland is characterised by the formation of a hyalin, semi-translucent, jelly-like substance containing brownish granules. It is an albuminous body, peculiar in containing iodine. A similar substance forms and dilates the glandular alveoli of new growths. As a further stage the epithelial cells become partly colloidal, partly destroyed in the process. Colloid substances may be seen distending the tubules of the pituitary body, kidney, parovarium, and prostate, and between the tubular strands of the tumours described as endotheliomata. In carcinomata of the stomach, breast, etc., the colloid material gives chemical reactions resembling in some cases those of mucin, in other cases those of amyloid substance, staining brown with iodine.

Hyalin changes in the corneous layers and epithelial cell-nests produce keratin, a substance staining deeply with carmin and fuchsin.

1. **Cysts formed by distension of normally-existing cavities or spaces.**—These are lined by epithelium or endothelium, which may degenerate, and their wall is composed of the condensation of inflammatory fibrous tissue (Fig. 57). They have a more or less spherical outline, are circumscribed and defined from the surrounding tissues, from which they generally are separable with ease. They cause symptoms by the pressure they exert on surrounding structures, or burst and discharge their contents on a cutaneous, mucous, or serous surface without or after previous suppuration, or shrink and the wall undergoes fatty or fibrous degeneration and calcification.

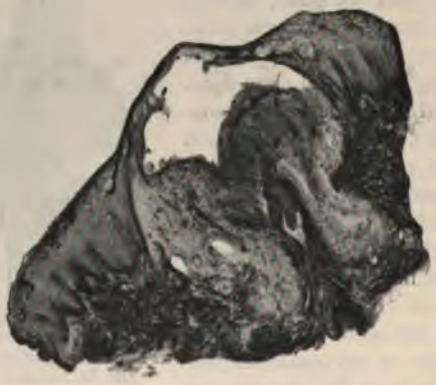

FIG. 58.—Labial obstruction cyst. Photograph of a section through a cyst removed from the inner surface of the lip. The superficial wall of the cyst is formed by epidermis. The contents were partly fluid, partly granular débris. Below are two ducts joining one another to form the main duct, which became obstructed at its mouth.

(*a*) *Retention cysts* form in glandular organs or tubes when the main duct or some of the secondary ducts become blocked (Fig. 58). This may be due to inspissation of the secretion, to a concretion or calculus, to inflammation or stricture of the wall of the duct, to external pressure on the duct, to a foreign body impacted in or pressing on the duct. Instances of retention cysts are: in the salivary glands forming a ranula, in the mammary gland a galactocele, in the bile duct distension of the gall-bladder, also a pancreatic cyst, the ureter blocked causing hydronephrosis, encysted hydrocele of the testis, a labial cyst from obstruction of the duct of Bartholin's gland. Sebaceous cysts in the skin are common; also small mucous cysts arise on the lip and in the mouth. Mucous canals may become obstructed and form cysts, as the Fallopian tubes when closed at each end, the appendix when shut off by inflammation from its

connection with the cæcum. Mucus collects in cavities by closure of the orifices, forming mucoceles, *e.g.*, in the maxillary antrum, frontal sinus, lachrymal sac and mastoid cells.

(*b*) *Exudation cysts.*—An excessive secretion or a pathological exudation distends cavities which have no excretory duct. Bursæ become distended, ganglia arise by a portion of a tendon sheath being shut off by inflammation and distended with fluid.

(*c*) *Extravasation cysts* are due to extravasation of fluids, blood, bile, urine, or chyle, into a closed cavity, such as the tunica vaginalis, to form a hæmotocele, into the meninges or into portions of the pleura or peritoneum, where the fluid becomes enclosed or encysted by inflammatory exudation.

(*d*) *Lymph and chyle cysts.*—Either as the result of obstruction, from an unknown cause in this country, or in consequence of infection in the tropics by filiaria sanguinis hominis, the thoracic duct, or some of the lacteals, or one or more of the lymphatics in a limb may become obstructed and give rise to a single or multilocular cyst containing lymph or chyle, or the contents may escape on the surface (lymphorrhœa), or into a serous cavity (chylous hydrocele), or into the urinary tract (chyluria).

2. **Congenital cysts.**—A fœtal structure, whether gland or duct, which has not been obliterated may become distended by fluid, or its cells may undergo cystic degeneration, or epidermal or endodermal remnants may be displaced, or a normal structure may be ill-developed, *e.g.*, ducts imperfectly connected with alveoli or lymphatic spaces not communicating freely with lymphatic trunks, the contents of the cerebro-spinal canal imperfectly enclosed, resulting in encephaloceles or meningoceles. The remnant of the Müllerian duct forms an encysted hydrocele from the hydatid of Morgagni, or a cyst originates from the uterus masculinus behind the bladder; the remains of the Wolffian body in the parovarium or the ducts of Gærtner, give rise to cysts lined with ciliated epithelium. Cysts lined with columnar ciliated epithelium are found in connection with the thyro-glossal tract, the trachea, larynx, and œsophagus. The urachus and Meckel's diverticulum, when persisting and being shut off from their junction with the bladder or intestine, become dilated. Hydroceles arise in the unobliterated funicular portion of the tunica vaginalis, forming the encysted hydrocele of the spermatic cord in the male, and that of the canal of Nuck in the female.

A dilatation of lymphatic spaces in the neck, axilla, loin or groin gives rise to congenital cystic lymphangiomas, or hygromas. Between the cysts is intra-cystic fibrous tissue, or lymphadenoid, fatty or nævoid tissue.

Dermoids are the most striking of the congenital cysts. They occur alone or in combination with other fœtal remnants, or as part of a teratoma.

Dermoid cysts of the simpler kind have a wall composed of the

structures forming the skin and its appendages, viz., stratified squamous epithelium, dermis, hair-follicles with hair, sebaceous glands actively secreting their contents, also subcutaneous fat and sweat-glands (Fig. 59). They are commonly met with :—(*a*) in the skin of the scalp, or (*b*) attached to the periosteum and quite separate from the skin, above the outer angle of the orbit, (*c*) in the middle line of the floor of the mouth, below the tongue, (*d*) in the lines of the embryonic fissures in the neck, (*e*) in connection with the thymus, (*f*) in connection with the ovary in the female, and (*g*) between the bladder and rectum in the male. The more *complicated dermoid*

Fig. 59.—Wall of a dermoid cyst. Photograph through a papilla on the inner wall of an ovarian dermoid cyst. Stratified squamous epithelium covers the surface, beneath in the dermis are lobules of sebaceous glands, and below this hair-follicles cut across in various directions, and fat.

cysts which merge into the teratomas are especially those connected with the ovary, with the base of the skull around the hypophysis protruding into the naso-pharynx as hairy polypi, and with the spinal column. The dermoid cysts of the scalp are commonly called *wens*, also *atheromatous cysts*, from their porridge-like contents. They were formerly confused with the sebaceous cysts due to obstruction.

The material contained in these cysts is secreted by the sebaceous glands, and has a characteristic odour. It is greyish, porridge-like when stearin prevails in the composition of the fat, or is a fluid yellow oil at the temperature of the body when olein is in excess, and this latter is especially found in ovarian dermoids, and in those between the bladder and rectum of the male. The oil sets on cooling. Hair

may be absent, or if present, downy like that of the fœtus; one long hair may be coiled up, a bunch of hairs may project from a prominence into the cyst, or a mass of hairs may be rolled up into a ball. The cyst may burst, and the hairs appear on the surface, *e.g.*, of the bladder, or naso-pharynx.

Dermoid cysts may be noted immediately after birth, especially on the forehead, but are remarkable in often remaining dormant even until quite late in life. Sometimes they have been found under the tongue, quite small at birth, and have remained stationary until puberty; on the scalp they may not be perceptible until even late in life, and then may keep on appearing. They occur in both men and women, but especially in several females of the same family. In the ovary dermoids form abdominal tumours, appearing in children, but generally not until long after puberty. They tend to be multiple on the scalp, and are often bilateral in the case of the ovary.

Dermoid cysts continue to grow and exercise pressure in the abdomen; under the tongue they hinder swallowing, and in the neck or anterior mediastinum impede respiration. They may burst on the skin, and form a fungous tumour, or the secretion may become inspissated and develop a horn, or the cyst may give rise to a malignant ulcer. They may burst into the urinary or intestinal tract, and hair or oil be passed. A cyst of the ovary may rupture, and a secondary growth of scattered dermoids follow in the peritoneal cavity. Squamous-cell carcinoma often supervenes in the cyst wall, especially when the cyst is in the ovary.

3. **Cysts of new formation.**—(*a*) *Epithelial implantation cysts.*—A fragment of epithelium, also of skin including a hair-follicle, may be carried through a puncture, into the subcutaneous tissue of a finger or elsewhere, or into the anterior chamber of the eyeball. The epithelium may afterwards grow to form a cyst. A small painless tumour may then appear beneath the scar on the finger containing epithelial débris; or a hair may grow after its implantation upon the iris into the anterior chamber.

(*b*) *Inflammatory serous cysts* arise by inflammatory exudation into connective-tissue spaces. The inflammation may be set up by pressure over a bony prominence, and a so-called *adventitious bursa* develop. A foreign body, such as a bullet or needle, when the source of the irritation may be closely encapsuled by fibrous tissue, or it may lie free, surrounded by fluid distending the capsule.

(*c*) *Blood-cysts or hæmatomata.*—A blood-cyst may arise by the dilation of a varicose vein in the thigh or neck, the communication with the vein either being shut off or persisting, or it may arise by extravasation of blood, around which inflammation goes on to form a fibrous capsule; meanwhile the serum may be absorbed leaving the dried blood-clot, or the blood-clot may disappear except for hæmatoidin crystals whilst the serous contents remain. If near the surface,

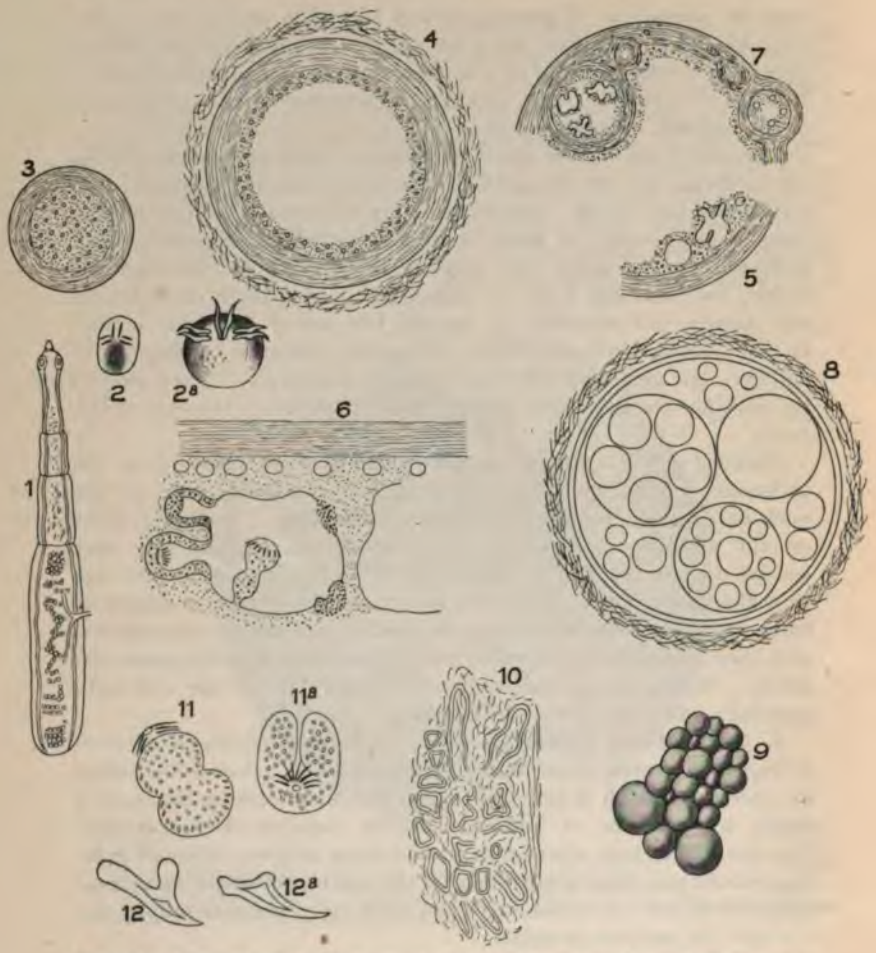

Fig. 60.—Diagrams of an echinococcus cycle, arranged after Leukart, Ziegler, and Lendon. 1. The tape-worm, about 6 mm. in length, appearing like chalk-white dots in the duodenum of the dog. 2. An ovum, about 0·01 mm. in diameter, indistinctly showing the six-hooked embryo. 2a. The six-hooked embryo free from its shell. 3. An hydatid cyst differentiated into an outer laminated layer surrounding granular parenchyma. 4. The acephalocyst stage. An outer elastic laminated layer and an inner parenchymatous layer of cells and granules, both non-vascular, enclosing fluid. Around the parasitic cyst a capsule of fibrous tissue with blood-vessels composing the adventitious cyst forms. 5. Brood capsules commencing to form in the inner layer when the cyst has reached to about the size of a walnut. 6. A brood capsule showing the development in it from a mass of coarsely granular protoplasm of a scolex or tape-worm head. 7. Daughter cysts forming from the granular protoplasm of the inner layer, and coming to resemble the mother cyst in having an outer laminated and inner parenchymatous layer, one also forming brood capsules. The daughter cysts may bulge inwards and make the mother cyst multilocular, or bulge outwards and make the mother cyst lobulated. 8. Daughter and grand-daughter cysts. 9. A grape-like mass of daughter

suppuration and an abscess may result. Common instances are—the cephal-hæmatomas of the scalp arising during birth or subsequently from injury, in the brain in apoplexy or after injury, in the ear, *hæmatoma auris*, or as a result of rupture of muscle.

4. **Parasitic cysts.** (*a*) **Cysticercus cellulosæ.**—This is the bladder stage of tænia solium, the tape-worm which inhabits the human intestine. The cysticercus forms small spots called "measles" in the flesh of the pig, from which it gains entrance to the human stomach or intestine in imperfectly-cooked flesh. The cysticercus in man is rare in this country. It forms a single spherical swelling, about the size of a marble, in the subcutaneous tissue. Very rarely it is multiple, when, scattered over the skin, the condition has been mistaken for molluscum fibrosum. It is also seen in the vitreous chamber of the eye, and in the brain may give rise to epilepsy. The cyst is composed of a white wall containing clear fluid, and the head of a scolex with a rostellum, row of hooklets and suckers, or the cyst may be sterile. Such a cysticercus is due to eggs or proglottides of the tape-worm. On reaching the human stomach, where the egg-shells are dissolved, the hooked embryo escapes and bores its way through the stomach wall into the circulation, by which it is carried to a favourable spot for developing into the cystic stage.

(*b*) **Hydatid or echinococcus cysts.**—*Development.*—Hydatid cysts are the bladder stage of the tape-worm, Tænia echinococcus, which inhabits the intestines of the dog. Dogs obtain the worms by eating the flesh of cattle diseased by hydatids, the cattle being infected through the ova in dogs' excrement reaching the stomach. The disease is now rare in this country, but it is very common in Australia and in Argentina owing to numbers of carcases and offal of diseased cattle left about for dogs to eat. It is also frequent in Iceland, where, owing to the cold and to the scanty supplies of fuel, the inhabitants for the sake of warmth are accustomed to huddle together with their dogs in single rooms. In this country the history of contact with a dog or the reverse is not of much value as regards diagnosis.

Before the ova from dogs' excrement reach the human stomach, whilst in the proglottides of the parent worm, the embryo has developed six hooklets (Fig. 60) directed backwards. On reaching the stomach it is hatched, and aided by its hooklets presumably

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cysts, the mother cyst having disappeared. 10. Shrinkage of the mother cyst causing the parasitic wall to be folded, and between these folds is vascular fibrous tissue belonging to the adventitious cyst, the whole forming a semi-solid or solid mass, having an alveolar honeycomb-like foliated appearance on section, compared to the heart of a cabbage, or resembling a colloid carcinoma. 11. Scolices or heads of tape-worms, with the rostellum and hooklets protruded or retracted, like a vorticella. They are just visible as specks when the fluid in a glass is held up to the light, and measure in full protrusion about 0·3 mm. 12 and 12*a*. Hooklets, highly magnified.

makes its way, either directly towards the liver, or gains access to a branch of the portal vein, whence it is carried to the liver, or further to the lung or into the general circulation as an embolus. It then proceeds to develop into a cyst, but the stages between the hatching of the embryo and the formation of a cyst a month to six weeks later have not yet been traced by experiment. The development takes place most commonly in the liver, whether near the surface, or deeply, also in the lung or pleural cavity, in the spleen or somewhere in the abdominal cavity, in the brain, subcutaneously, or in the medullary cavity of bone. The wall of the cyst is formed by the parasite, and around this a fibrous inflammatory capsule develops from the patient's tissues. The terms ectocyst and endocyst have been variously applied, by some to the fibrous adventitious capsule and the parasitic cyst wall respectively, by others to the two layers of the parasitic cyst wall itself. The parasitic cyst wall is glistening white, like hard-boiled white of egg, and has about the consistency of cooked macaroni. It is divided into an outer elastic *laminated* layer and an inner *parenchymatous* layer of cells and granules. The capsule of vascular fibrous tissue which forms the wall of the adventitious cyst has a variable thickness. The non-vascular parasitic cyst is hardly attached to it at all; thus unlike an encapsuled tumour there is no vascular connection, the parasite living by diffusion. The parasitic cyst is filled with a clear or slightly opalescent fluid, of very low specific gravity, containing much chloride of sodium, also oxalates and phosphates of lime, traces of sugar when the cyst is in the liver, urea, but no albumen, and crystals of cholesterin; hooklets and scolices may be found in the deposit from the fluid on standing. When the parent parasitic cyst has developed to the size of a walnut or before, small vesicles or brood capsules, seen as opaque spots, form in the parenchymatous inner layer. At a point in the wall of the brood capsule there collects a mass of coarsely granular protoplasm, which next shows an involution communicating with that of the brood capsule, and is then differentiated into a scolex or tape-worm head, which has on its front end a rostellum with a row of hooklets, four suckers, a water vascular system, and refracting bodies composed of lime. The front end may be drawn or invaginated into the hinder. The cyst may remain simply unilocular, enlarging by increase of fluid and by brood capsules in its wall forming scolices. Or daughter cysts may arise from the granular protoplasm of the inner layer of the mother cyst, which they come to resemble in having an outer laminated and an inner parenchymatous granular wall, from which in turn secondary brood capsules and scolices are developed. These secondary or daughter cysts may fill the mother cyst and cause it to be multilocular, or protrude from the surface, giving the mother cyst a lobulated appearance, or become detached, especially after the rupture of the mother cyst, when they may start an isolated existence, become surrounded by a separate fibrous

adventitious cyst, and develop in turn tertiary or grand-daughter cysts. A mother cyst may not develop brood capsules at all, but remain sterile, without scolices or hooklets, especially within the skull, and is then called an acephalocyst. In the brain or pleura only a very delicate fibrous adventitious capsule may develop. In the shaft of bones no adventitious cyst or mother cyst may be found, only a grape-like mass of daughter cysts, lying freely in the distended cavity.

Degeneration.—An hydatid cyst may cease to grow, die, and its contents be converted into a jelly-, putty- or mortar-like mass. Calcification may occur in the fibrous adventitious cyst, or this being thrown into folds and remaining vascular intermingles with semi-solid remains of the parasitic cyst to form a tumour, having an alveolar, honeycomb-like or foliated section. In such cases the hooklets remain undestroyed.

Rupture.—A cyst may burst spontaneously either before or after suppurating. It may discharge into the peritoneal cavity causing shock and an attack of urticaria, followed by the development of the scattered daughter cysts. But should suppuration have already begun, virulent fatal peritonitis will be set up. A cyst of the liver, pleura or lung may burst into the respiratory tract, parasitic membrane may be coughed up, and the patient recover, or he may be suffocated at once or die later from septic absorption. The cyst may burst:—into the biliary tract and set up acute colic and biliary obstruction; into the intestinal tract; into the pelvis of the kidney causing signs of renal colic; into the bladder and produce retention of urine from impaction in the urethra; into the brain and cause fatal apoplectic symptoms, or externally through the abdominal wall after pointing.

Hydatid cysts may develop singly or be multiple, and arise simultaneously or at intervals. In the liver, one, two or three distinct cysts may develop. They may reappear in the scar following an operation presumably due to infection at the time.

The *signs* of a hydatid cyst vary with its situation. It generally gives rise to a sensation of a tense globular swelling before degeneration has set in. It may fluctuate if not very tense, and the sensation of percussing a mass of jelly has been deemed peculiar to a hydatid cyst and called *hydatid thrill* or *fremitus*, but this is not a necessary sign. A relative absence of symptoms may aid in the diagnosis by exclusion, *e.g.*, in the case of a liver tumour. In Australia its relative frequency is so great, *e.g.*, 1 in 200 of hospital cases, that the existence of hydatids may be the more often suspected.

Prevention.—Inspection of meat and its destruction when found infected, including the entrails, will prevent dogs from devouring hydatids. A dog may be rid of the worms by anthelmintics. Cleanliness in its kennel and the destruction of its excrement will prevent ova or proglottides from being swallowed by cattle.

Distribution of hydatids.—The percentage occurrence of hydatids

among 1,900 cases was found to be: Liver 57, lung 11·6, brain 4·7, spleen 2·1, heart 1·8, peritoneum, omentum and mesentery 1·4, muscles 7, female organs and breast 4, true pelvis 3, spleen and bones 3, vessels 2.

Hydatids of the *liver*, *lungs*, *brain* and *bones* will be described under those heads.

Among the *rarer forms* may be noticed hydatids compressing the spinal cord, or growing in the orbit and displacing the eye, or in the thyroid gland, three out of six cases proving fatal from perforation of the trachea. A cyst of the female breast has proved to be an hydatid. In the abdomen, besides the connection with the liver, the spleen may be affected, a cyst may be attached to the omentum or mesentery, or after rupture the whole peritoneal cavity may be sown with cysts. A cyst is likely to settle down and develop in the recto-vesical pouch of the male, and in Douglas's pouch in the female, or may pass into the scrotum through a patent funicular process. Hydatids discharging through the uterus require to be distinguished from an hydatidiform mole.

General treatment of cysts.—Wherever possible a cyst should be removed completely, either by shelling it out or dissecting it away from the surrounding structures, or by tying the pedicle if there is one. This is especially the case with all epithelial cysts, whether retention-cysts or those of new formation, any remains of the wall being able to cause the cyst to re-form. In some cases where, as in the salivary gland or bile duct, or ureter, the retention is due to some removable cause such as a calculus, it may be sufficient to deal with this. A fibrous cyst, although not lined with epithelium, should generally be dissected away, especially if the wall is formed by a tumour or of thick inflammatory tissue, such as a bursa. If this cannot be done, then the contents should be completely evacuated through a free incision, and the cavity filled with gauze, which is renewed at each dressing until healing occurs. Only rarely can a cyst with a thin wall and serous contents be evacuated and sutured, nor is a drainage tube so good as gauze, for fluid is apt to remain in the cavity and decompose. An hydatid parasitic cyst is completely shelled out from the adventitious when it is vascular as in the case of the liver, or near important structures such as the brain, great care being taken to remove the whole of the parasitic membrane without setting up hæmorrhage. Degenerated and small hydatid cysts are dissected out, adventitious cyst and all, whenever this can be done.

Aspiration, except for diagnosis, must be immediately followed by evacuation. It has been very rarely successful even with a thin yielding wall and serous contents. Tapping hydatid cysts is a much more dangerous method than incision, quite apart from the question of cure. Injection with iodine should never be employed; it is not only useless, but dangerous. Even in cases of thin-walled lymph cysts, meningoceles, etc., excision is much better.

SECTION II.

General Pathology of Injuries.

WOUNDS.

Repair of Wounds.

A wound is a solution of continuity in any part of the body, suddenly made by cutting or tearing. Formerly a sharp distinction was drawn between an *open* wound, in which the skin was divided, and a *subcutaneous* wound, in which the skin remained intact. But the difference between the two is merely one of relative liability to septic infection, which was in the case of open wounds practically inevitable until the introduction of antiseptic surgery by Lord Lister. A subcutaneous wound, in which the skin remains intact, may yet be infected from the surface when superficial, as frequently happens in the case of a subcutaneous hæmatoma, or through the circulation when deep. Moreover, the term *subcutaneous* wound was often used in connection with the methods of so-called "subcutaneous surgery," *i.e.*, punctured wounds were made with a narrow knife (tenotome), when the chances of infection were small, although there was an absence of all the preventative measures now employed.

The *process of repair of wounds* will be here treated generally as applying to the skin and soft parts, whereas wounds of special tissues, such as bone, muscle, nerve and blood-vessels will be referred to separately.

The process of repair is found when investigated microscopically to be similar to the regenerative stage of inflammation. When not disturbed by the presence of active pyogenic organisms it consists mainly and primarily of regeneration of tissues by fibroblasts and proliferating epithelial cells, with only a little preliminary emigration of leucocytes and pathological exudation, varying according to the amount of damage to the tissue by the wounding. Regeneration being hindered from setting in immediately after the wounding by the presence and activity of pyogenic organisms, leucocytic emigration and pathological exudation take place profusely, suppuration is started and involves the tissue cells, which would otherwise carry out regeneration. Thus regeneration is delayed, is no longer a primary, but becomes a secondary process, and only brings about healing when the inflammation has subsided.

Healing by first intention.—This is a primary process of regeneration by the cells of the tissues bordering on the wound to

replace those destroyed by the wounding. It is that which occurs naturally whenever the margins of the wound are in contact or approximately so, and no active pyogenic organisms or other foreign material hinder the starting of the process. The variations observed are due to the characters of the wound (see *Varieties of Wounds*), according to whether little or much of the tissues has been so damaged as no longer to be capable of living and proliferating, but dying have to be removed by phagocytosis and absorption. Also variations occur during healing according as the wound is properly dressed and kept at rest, and the patient's general state of health and his hygienic surroundings are cared for.

It is not that healing by first intention requires the wound to be absolutely free from germs. Bacteriological experiments seem to show that organisms can always be found in connection with such a wound, in particular staphylococci, but the point is that their activity is so small as to be overcome by phagocytosis.

Naked-eye description of repair by first intention.—A simple incised wound being inflicted in a healthy subject hæmorrhage occurs according to the vascularity of the part, the blood spouting in jets from arteries, flowing from veins and oozing from the smaller vessels and capillaries. The hæmorrhage being arrested, and measures taken to prevent septic infection, the wound accurately closed and kept at rest with its surfaces in contact, adhesion and then union will occur with hardly any or no signs of inflammation (simple or adhesive inflammation). The edges of the united wound, inspected at any time up to eight days, will present no difference from its appearance at the end of suturing, or there is but a very slight redness and swelling. If an attempt now be made to draw the edges apart, as for instance when an operation is done by two stages with an interval of a few days, they will be found stuck together by a white adhesive material which on the surface between the edges becomes dried. After a week or so the line of union becomes red, and if the margins of the wound be now separated there is some oozing of blood, showing that new vessels are forming; gradually the streak becomes paler, till ultimately a thin white line alone indicates the site of the injury, and this may in time become almost imperceptible. If cut into, the margins are now found firmly united by white fibrous tissue.

If from any cause the surfaces of a wound are not brought wholly into contact, the space becomes filled with blood which coagulates. If the superficial edges are apart this blood-clot fills and bulges above the surface, where, especially in small wounds, on the cessation of hæmorrhage it dries into a scab. Formerly attention was drawn to the fact that small wounds healed under this dried scab. Especially was this the case with the smaller wounds of animals, where the hair, thick skin, and valvular character of the wound, together with the healthy life of the animal, protected it from septic

infection. It was then supposed that the blood-clot took some active part in healing, and it was spoken of as a special process, *healing by blood-clot*. It is now recognised that the scab made by the dried clot simply protects from contamination like a dressing, also that blood-clot is not a good thing between the margins of a wound. In small amount the fibrin may serve as a scaffolding to be replaced by tissue-cell proliferation. But in any considerable amount the breaking-down and removal of the red corpuscles entail the absorption of toxic products. The patient may even be slightly jaundiced by the pigment resulting from broken-down hæmoglobin; and also organisms have a great tendency to actively develop in blood-clot, and so promote suppuration. Therefore, blood-clot is now prevented as far as possible from collecting in a wound.

Microscopical description of healing by first intention.—In consequence of the injury inflicted on the tissues by the instrument making the wound, increased by exposure to cold air, irritation of strong antiseptics, etc., some cells are killed outright, others

FIG. 61. — Diagram representing a simple incised wound, immediately after the incision has been made.

FIG. 62.—Diagram representing an incised wound a few hours after the incision. A. Area of thrombosis — leucocytes making their way to the cut surface. B. Area of dilated capillaries—leucocytes escaping from the vessels into the tissues. C. Normal tissues.

damaged so far that they cannot take part in the regeneration, and more or less of blood-clot in a thin layer covers and connects the surfaces. The divided vessels contract and retract, so that the blood-flow is arrested by a thrombus or clot (Figs. 61, 62). Thrombosis and stasis having taken place at the cut ends of the vessels, a retarded flow ensues behind the thrombus, and leucocytes begin to emigrate and fluid to exude, whilst a little further back there is some dilation and accelerated flow which may give rise to a faint blush of redness (Fig. 63) on the skin. The emigrated leucocytes and the pathological exudation collect among the irregularities of the wounded surface, giving it a glazed aspect, and infiltrate the blood-clot between the adjacent margins (Fig. 64).

Commencing within eight or ten hours, and becoming active in a day or two, there follows a proliferation of connective tissue and endothelial cells (Fig. 65), whilst the leucocytic emigration and the exudation from the blood-vessels are arrested. The cells resulting from

proliferation invade and remove the blood-clot and leucocytes, so that the interval between the surfaces becomes filled by cells having a darkly-staining nucleus surrounded by a little protoplasm. These cells now become fibroblasts and ultimately develop into a fibrous scar, whilst newly-formed capillaries appear.

A new capillary is formed by budding from the walls of the cut capillaries behind the level of thrombosis and stasis (Fig. 5). The endothelial cells grow and divide by karyokinesis, producing a tent-like elevation on the side wall of a capillary or are prolonged into a fine thread of granular protoplasm containing nuclei. This process meets another of the same kind, or unites with an already existing vessel, and becomes a hollow channel through which blood begins to flow, whilst nuclei and protoplasm group themselves and differentiate into cells, the outlines of which

FIG. 63.—Diagram of an incised wound a day or two after the incision. The sides of the wound united by small round cells.

FIG. 64.—Diagram of an incised wound a few days after the incision. Loops of capillaries growing out from the old capillaries and making their way amongst the small round cells uniting the cut surfaces. At the lower part of the figure a loop has united with one from the opposite side.

can then be demonstrated by staining with nitrate of silver. Whilst this vascularisation is in progress, the fibroblasts derived from the connective tissue are developing into scar tissue. At first (see Fig. 4), the cell has an oval nucleus with only a little protoplasm, then the protoplasm increases, whilst there appear two or more nuclei. Processes develop, so that the cells next appear oat-shaped or spindle-shaped, and with their long axes arranged parallel. Then parts of the cell become fibrillated, also the homogeneous intercellular substance develops fibrils, whilst the nucleus remains elongated, surrounded by a scanty amount of protoplasm. The young fibrous tissue later on undergoes contraction, so that the newly-formed capillary loops are constricted and obliterated, their endothelial cells sharing in the general fibrous change, until the scar becomes relatively non-vascular.

The blood-clot between the surfaces of the wound is removed by active phagocytosis (Fig. 6) on the part of leucocytes and of cells derived from connective-tissue cells and from endothelium. The fibrin and red corpuscles are in part taken into the cells and digested,

in part rendered soluble by a proteolytic ferment derived from these cells, and so are easily absorbed into the lymphatics and veins.

Healing by first intention is prevented by: (1) Septic infection, (*a*) from lack of care in preventing it at the time of making the wound; (*b*) in the case of an accidental wound from the impossibility of removing, or the failure to remove, the septic matter,

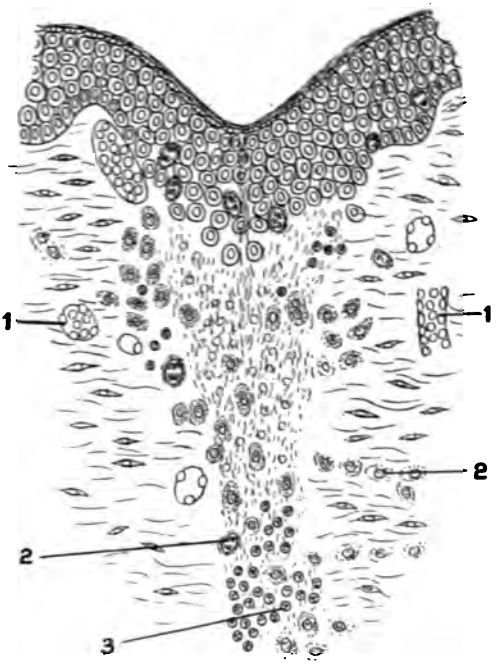


FIG. 65.—Wound healing at the end of a week. Semi-diagrammatic, after Ziegler. The union of the epithelium is marked by a depression, and in the Malpighian layer near each margin some cells are dividing and showing karyokinesis Beneath the epidermis fibrin, blood corpuscles and leucocytes are disappearing. The blood capillaries, 1, 1, whilst still dilated, show no signs of emigration of leucocytes. 2, 2, Connective-tissue corpuscles and endothelial cells are dividing to become, 3, small round cells, which then go on to form spindle cells and fibrous tissue as in Fig. 4; whilst serving also as phagocytes (see Fig. 6) they remove the fibrin, red blood corpuscles, and leucocytes, which first occupied the wounded surfaces.

whether attached to foreign bodies or not, carried in at the time of the accident; (*c*) infection from some abscess or septic cavity communicating with the depth of the wound; or (*d*) infection through the circulation, the infection existing at the time of the wound somewhere in the system or gaining entrance subsequently. (2) Injury to the tissues forming the margins of the wound by contusion, laceration, rough handling and excessive use of antiseptics. (3) The parts not being kept at rest in apposition. (4) Inefficient

drainage, the serum derived from the blood-clot and from the inflammatory exudation collecting between the surfaces of the wound and setting up tension. Thus the wound surfaces are separated by the serum, which by its tension compresses newly-formed blood-vessels, and the toxins contained in the serum check regeneration. (5) An impaired state of health, from causes such as alcoholism, albuminuria, diabetes, etc. These, whilst not actually preventing healing by first intention, favour the development of any chance infection by diminishing the resistance presented by such patients.

Healing by second intention.—In healing by second intention, the setting in of regeneration by fibroblasts and epithelial cells is delayed, being hindered by the amount of degeneration which first ensues. A period of suppuration if the wound has been closed, of ulceration if it remains open, takes place before healthy granulations form, and it is then only that definite repair begins. The process of healing by granulation (Fig. 66) may take place after only a small amount of ulceration, after marked inflammation and ulceration or more or less of free suppuration for a considerable period.

Fig. 66.—Diagram of granulating wound.

(*a*) *Healing by second intention after only a small amount of ulceration.*—A wound which is not brought together because its surfaces are already infected, or in which there has been such a loss of substance that it is impossible to unite it, the bleeding being arrested, may be dressed with gauze. The result is that the inflammatory exudation which quickly ensues is immediately taken up by the gauze and prevented from decomposing, and there is then only a limited amount of ulceration of the surface and surrounding inflammation, with the escape of a thin reddish discharge, not containing many cells, and when the gauze is raised, a dryish glazed surface is exposed. Within a few days the whole of the wound is covered by small red elevations, granulations, which tend to fill up all the depressions in the wound to a uniform level. If now the edges and surfaces of the wound are well approximated, the surfaces will adhere and unite, rather more slowly than in healing by first intention, and with the escape of some reddish cellular discharge, followed by the formation of a greater amount of fibrous tissue, and so more contraction of the scar. This union is called, *union by granulations*, *by secondary adhesion*, *union after secondary suture*. Supposing it impossible to bring the edges together, healing occurs after healthy granulations have formed, either by epithelium spreading inwards from the margin or after skin-grafting.

(*b*) *Healing by second intention after marked inflammation and ulceration.*—Supposing considerable injury to be done so that parts of

the edge and surface die, whilst pyogenic organisms are introduced, and the discharges are allowed to remain on the wounded surface and decompose, the immediate result of the wounding is acute inflammation of the wound and its surroundings for some distance, ulceration with profuse discharge of pus, along with the constitutional symptoms of *septic intoxication, hectic fever.* The wound is covered by thick pus and dead tissue, or sloughs (see Gangrene). This septic inflammation may spread. Supposing it not to do so, the sloughs and pus will diminish in amount, whilst the surrounding inflammation subsides until the redness and swelling are confined to the neighbourhood of the wound. At the same time red granulations begin to form and appear through the pus here and there, gradually becoming more numerous as ulceration lessens. Finally, the wound is covered with healthy granulations, but there is a great amount of fibrous tissue in the base of this chronic ulcer. When healing finally is completed, whether by the drawing of the edges together, the spread of the epithelium from the periphery, or after skin-grafting, much contraction will ensue, and a puckered scar permanently marks the site of the injury.

(*c*) *Healing by second intention after suppuration.*—Supposing an infected wound to be sutured, especially if imperfectly drained, or if the infected wound be of a punctured character, there is acute suppuration and the formation of an abscess between the surfaces of the wound. This abscess must discharge and the suppuration subside before the regeneration process necessary for repair can set in. Inflammatory redness with swelling commences at the edges of the wound at once, and instead of subsiding increases and spreads for some distance around, the parts become tense, and throbbing pain is felt. Meanwhile the patient feels chilly or has a distinct rigor, the temperature rises, the pulse increases in frequency, the tongue becomes coated, the skin hot and dry, the urine scanty and high coloured, and the bowels confined. There is headache, loss of appetite, restlessness, want of sleep, and perhaps some delirium. The patient is now suffering from *septic intoxication* (*septic traumatic fever*), the result of absorbing toxins formed between the wounded surfaces. The septic process may extend, and the patient suffer from *septicæmia* or *pyæmia.* If, however, free exit be given to the pus and broken-down blood-clot, the absorption producing the septic intoxication is checked, the constitutional symptoms subside, and the opposing surfaces of the wound become covered with granulations and unite. The union takes place last of all in the track of the drain and the opening in the skin, where healing may be long delayed and a sinus persist.

The microscopical appearances in healing by second intention are described under ulceration and suppuration. Pus is formed both by leucocytes and by the proliferating tissue cells, the latter continuing to die, killed by toxic poisoning, and to fall off as long

as the acute inflammation lasts. When this subsides, some of the proliferating tissue cells begin to form fibroblasts, and the endothelial cells new capillary loops. A capillary loop surrounded by a heap of potential fibroblasts forms the red mass, called a granulation. If not destroyed by toxins, the fibroblasts of the granulations form fibrous tissue, while the epithelial cells at the margin begin to spread over the granulating surface. An excessive amount of fibrous tissue is formed, which after the epithelium has covered it in still remains vascular, as shown by the red surface. But although more slow to begin, contraction of the fibrous tissues proceeds until the scar remains both thicker, denser and less vascular than after healing by first intention.

Treatment of Wounds.

Wounds tend to heal by first intention, and are chiefly hindered from it by septic infection or hæmorrhage. To prevent these occurrences special measures are required not only in connection with the operation or first dressing after an accident, but also until healing is complete. Special treatment is required for the constitutional effects of injury; also for special varieties of wounds, burns and scalds.

The prevention of septic inflammation in wounds.

Healing after more or less suppuration was regarded as the normal course, and that by first intention the exceptional, until Lord Lister showed that by the scientific use of chemical materials acting as *antiseptics*, germs which would otherwise or had actually come in contact with a wounded surface, might be destroyed, or at any rate so inhibited that they do not set up inflammation. Since then heat for destroying germs has been used in a number of ways, included under the term *aseptic measures*. Antiseptic and aseptic measures are now used in combination to prevent septic inflammation without damaging the living tissues. Although in most cases no absolute freedom from organisms is at present really accomplished, yet the practical end, the prevention of septic inflammation rather than bacteriological sterility at all points, is as a matter of fact largely attained.

A. **Antiseptic measures.**—These involve the use of chemical antiseptic materials, of which there are many that have been tried, although here only those in common use are described—(1) Strong antiseptics, carbolic acid and perchloride of mercury; (2) weak antiseptics, permanganate of potash and boric acid; (3) antiseptics in powder, iodoform and boric acid; (4) antiseptic pastes; (5) antiseptic gauzes; (6) antiseptic wools.

(1) *Strong antiseptics.* (*a*) *Carbolic acid.*—Only the purest form is used in surgery. The crystals should have no other than the characteristic odour; on warming, or on the addition of a little water,

a thick clear syrup results, which is used as such or diluted to the stock solution.

(i.) Undiluted carbolic acid destroys all germs in contact with it without penetrating or destroying tissues beyond the surface, and is used for swabbing limited septic areas, no excess being allowed to overflow, such as small foul and phagedenic ulcers, also tuberculous ulcers and sinuses, down which it is passed on a probe, with or without cotton-wool twisted round the end. It is also a local anæsthetic; hence no opium need be given after its use. A small flake of wool squeezed out of undiluted carbolic acid can be inserted into a hollow tooth to relieve toothache, or a drop may be put on a boil or pustule, and a puncture made through the drop.

(ii.) A 5 per cent. solution, *i.e.*, 1 in 20, made by diluting carbolic acid with boiling water, is the stock solution. It is poured over the instruments, ligatures and sutures laid in trays, five minutes before commencing an operation. Just before use, this solution should be diluted to 1 in 40 by the addition of an equal quantity of boiled water, or the hands will be numbed, and later will desquamate. When the operation is on the face, mouth, naso-pharynx, abdomen, bladder or rectum, this solution should be replaced by boiled water, and the instruments thus freed from the acid, lest small quantities be carried over and so absorbed. By means of sponges on holders the skin, infected wounds, and small abscess cavities are scrubbed and swabbed out with a hot solution, by which germs are rapidly destroyed, whilst the oozing of blood is checked. Sponges, silk ligatures, and rubber drainage-tubes are kept for at least twenty-four hours in this solution before use.

(iii.) The 2·5 per cent. solution, 1 in 40, is employed for swilling sponges and hands during an operation. Towels or lint are soaked in it for half an hour, wrung out dry, and then used for protecting the operation area.

Diluted to 1 in 80, carbolic acid may be used as a mouth wash.

To avoid blistering when carbolic acid is used undiluted, the skin around the ulcer or sinus may be painted with absolute alcohol. Hands shrivelled by 1 in 20 carbolic acid should be dipped in spirit.

Carbolic acid must always be entirely washed away from the skin and cavity of a wound by water; none should be left to be absorbed. It should not be used for irrigating the mouth or nose lest it be swallowed, nor for irrigating the bladder, rectum, peritoneal or large abscess cavity, for it is rapidly absorbed from such cavities, and cannot be all recovered by the after-irrigating with water.

It must never be used for fomentations applied to inflammatory areas and open wounds, for it is thus readily absorbed; also it causes superficial gangrene, especially of the fingers or toes, and inflamed skin, by contracting the blood-vessels.

It is used for disinfecting the skin before operation by wringing lint out of the 1 in 20 or the 1 in 40 solution, and applying to the

skin over the line of the proposed incision and a limited area around. For the thick skin of adults the 1 in 20 solution is applied not more than two hours before the operation; for thin skin, and in the case of children, the 1 in 40 solution, for not more than one hour beforehand; to the face in the neighbourhood of the eyes and mouth, no carbolic acid at all, only boric acid, should be used.

Carbolic-acid poisoning is avoided by the foregoing precautions. Absorbed in a small amount it turns the urine olive green, and forms with perchloride of iron a dark blue colour. Patients with kidney disease and children are specially susceptible. Malaise, drowsiness, or coma have been set up, *e.g.*, children have been rendered comatose by applying carbolic lint to the skin too long before the operation.

(*b*) *Perchloride of mercury* (mercuric chloride, sublimate or bichloride of mercury).—The stock solution is 1 in 1,000. Instead of the chloride, the corresponding iodide, or less often the cyanide, is employed as being less irritating. The perchloride solution is often tinged with analin blue, the iodide with rosanilin. Tabloids tinged in this way are the more useful as being portable, and the decomposition of the solution in presence of light, organic matter, etc., is avoided.

The 1 in 1,000 solution, or the solution 1 in 500 in spirit, is specially employed for scrubbing the skin and hands, or for swabbing out the vagina, and is applied to any infected surface, from which it can be easily swilled away with water. The solution 1 in 2,000 is used for swilling the hands and sponges during operations.

It is not suitable for instrument trays, because the mercury is precipitated and the solution rendered inert against germs, also it tarnishes plated and steel surfaces and blunts the edges of knives. It quickly erodes and destroys metal bowls, hence glass or china or enamelled ones are required in using it. It also destroys lead pipes and soldering, causing drains to leak.

It must not be kept in contact with the skin before operations, nor employed for fomentations, as it sets up a troublesome pustular eruption, even when applied for only an hour or two, particularly in patients who sweat freely.

Mercurial poisoning.—By observing the above rules and washing the solution away from the skin, wounds, vagina, etc., and not using it for operations on the mouth, naso-pharynx, peritoneum, bladder, rectum, no symptoms of mercurialism will arise. Fatal poisoning has been due to neglect of these, *e.g.*, irrigating the uterine cavity after delivery, when the placental surface rapidly absorbs the mercury, causing swelling of the gums, foul breath, diarrhœa.

(2) *Weak antiseptics, not likely to set up poisoning.*—(*a*) *Permanganate of potash solution.*—The Pharmacopœial solution is a 1 per cent. "Condy's" fluid, a 2 per cent. solution. It is sufficient to dilute to the colour of pale port wine, and the solution becomes inactive

when its ruby tint is lost. It is freely used for irrigating large wounds and abscess cavities, the mouth, nose, bladder and rectum; also for baths. The stain on the skin is removed by hot saturated oxalic-acid solution.

As a fomentation to very foul wounds gauze may be wrung out of a hot solution, 1 in 400. Hands which have been rendered foul may be steeped in such a solution, and then decolourised in a hot saturated oxalic-acid solution.

(*b*) *Boric-acid solution.*—This is the antiseptic used for all fomentations. Poultices are now never employed. The powder is dissolved in boiling-hot water, with which lint is saturated. The lint is then wrung out in a warm, or better sterilised, towel, immediately applied, and covered with pink protective. This is changed after two hours.

If boiled water has perforce to stand some hours before use, it is well to add boric acid to saturation, otherwise it is so weak an antiseptic that its influence for irrigation is inappreciable; still, it is often used in operations on the mouth and nose. For irrigating cavities, baths, etc., it is not so effectual as permanganate, but has the advantage of not staining the skin.

(3) *Antiseptic powders.*—(*a*) *Iodoform.*—This is a most valuable antiseptic on account of its relative insolubility. It dissolves continuously but slowly in the body-fluids liberating iodine. It is particularly of service in preventing decomposition on surfaces where there is such a free discharge that a more soluble antiseptic would be washed off or absorbed. The larger the crystals the more slowly it is dissolved. It is also of special service in tuberculous lesions, whether on the surface or in a cavity. It is employed therefore on foul wounds and ulcers of all kinds to promote healing by granulations, also for tuberculosis, and for inserting into mucous cavities, such as the mouth after removal of the tongue. As a 10 per cent. emulsion in glycerine it may be injected into tuberculous abscesses and joints; or a 10 per cent. solution in absolute alcohol and ether may be employed. Also it is combined with vaseline as an ointment, with collodion as a varnish, etc.

Iodoform poisoning.—After iodoform injections children have had a rapid pulse up to 180, a temperature rising to 103° F., acute nephritis, with hæmoglobinuria and collapse, followed by coma and death. But any danger from *iodoform poisoning* may be practically disregarded, for when patients were dosed with it in large amount for phthisis they reeked of it and everything tasted of iodoform, and yet they only became dizzy or drowsy. The local and general anæsthetic properties of iodoform, very small in extent, are to be explained by the relation of its chemical formula to that of chloroform. *Iodine poisoning* has occurred from the use of iodoform, and care must be taken that the drug does not decompose; in particular, the emulsion in glycerine should always be freshly prepared; also the kidneys must not be irritated by the simultaneous use of carbolic acid or

perchloride of mercury. Various modifications of iodoform tending to get rid of the odour have not come into general use.

(*b*) *Boric-acid powder.*—This has an advantage over iodoform in not smelling, but it is more easily soluble, hence it is not so serviceable, *e.g.*, on the tongue or where discharges are excessive. However, it can be used freely without danger to a healing wound.

(4) *Antiseptic paste.*—As a temporary dressing applied to wounds with or instead of iodoform or boric-acid powder, Mr. Cheatle has recommended mercury and zinc cyanide 400 grs., tragacanth 1 gr., carbolic acid 40 grs., sterilised water 800 grs., contained in a collapsible tube. Without touching or probing, or attempting to clear a wound, some of the paste is squeezed out on to it, and it is then covered by a layer of antiseptic gauze, which is left on until the wound can be dressed under all antiseptic precautions.

(5) *Antiseptic gauzes.*—Lord Lister first used a carbolic-acid gauze, *i.e.*, muslin saturated with carbolic acid which is fixed by resin, but this has gradually fallen out of use owing to its irritating character. Perchloride of mercury gauze has been also used, the gauze being tinged with methylene blue. But it is liable to set up a pustular eruption in patients who sweat freely in hot weather, and the antiseptic is very easily washed out.

Finally, Lord Lister introduced a cyanide gauze, now most generally saturated with a double cyanide of mercury and zinc and coloured pink with rosanilin. It may be applied dry or sprinkled with carbolic lotion, but much of the salt is washed out when the gauze is wrung out of water. This gauze very rarely irritates if well made so as to contain no free perchloride. Iodoform gauze, being troublesome to prepare, is more costly, and has a powerful odour. It is very generally employed in strips of several layers, or as a hemmed ribbon, for plugging cavities and sinuses. On account of properties mentioned above, iodoform continuously but slowly liberates iodine. This prevents decomposition in the cavities by absorbing the discharge as quickly as formed, and checks hæmorrhage by pressure, whilst shutting out contamination from the air such as may gain access through a drainage-tube. Thymol, boric-acid gauze, etc., are weak but not irritating materials.

(6) *Antiseptic wools.*—Perchloride of mercury wool, coloured blue, is inexpensive. Artificial sponges can be made from it, by first heating the wool to expand it, then twisting up a small amount in a square cut out of a single layer of gauze. This wool is employed generally outside gauzes, and may be saturated with serous discharges for a week or more without allowing decomposition. The serum saturates it and then dries into an odourless cake. It may irritate the skin in hot weather, and should not come in contact with a wound. Iodoform wool is more expensive.

B. **Aseptic measures.**—Boiling water and superheated steam, also dry heat, are employed for sterilising instruments and dressings.

(1) *Boiling water*, to which a little bicarbonate of soda is added (a 1 per cent. solution, about a teaspoonful to a pint) to increase penetration, can be employed in any vessel which has a tray or false bottom. There must be no rusting metal inside, or it will be precipitated on the instruments.

Instruments after use are scrubbed in hot soap and water with a nail-brush, swilled, and then boiled in this soda solution for five minutes, not much longer, or they will gradually lose their temper. Then the soda is wiped off with spirit, and the instrument polished. Shortly before an operation instruments not having on them any visible rust or dirt are placed in the steriliser and boiled for five minutes before being laid in the carbolic-acid tray with the exception of knives, the edge and temper of which are injured by the boiling. Squares of lint or pledgets of wool can be boiled in this way, and used at an operation as wipers, but they will not absorb much. Clean towels may be boiled, being protected from being burnt by the tray, wrung out, and used for protecting the neighbourhood of the wound.

(2) *Superheated steam* is generated in a special apparatus. All that is required for an operation, towels, instruments, wool sponges, gauze and wool cut to form the dressing, and bandages must be so packed in layers in a vessel from bottom to top, that the several articles can be taken out in the order they will be required at the operation. This vessel is now placed in the steam steriliser, the lid of which is clamped down and heat applied for an hour. The top of the steriliser is then raised for a while to let steam escape, lest it should condense and make everything wet. The material so sterilised should be picked out with forceps only when wanted, and should be exposed and handled beforehand as little as possible. Such dressings require frequent changing, as even with serous discharge they soon have a sour odour; on the other hand, they are non-irritating.

(3) *Dry heat.*—Some instruments, *e.g.*, probes, needles, may be sterilised in the flame of a Bunsen burner or spirit lamp, or dipped in spirit which is then lighted by a match. A dry heat steriliser of wrought iron can be used for sterilising wool, sponges, etc.

C. **Special preparation for operations.**—1. *Marine sponges* are the best absorbents, and in operations on the throat or abdomen are especially advantageous, yet owing to the difficulty in preparing and cleaning them they are now not generally used except in such cases. Marine sponges must first be freed from sand by prolonged kneading in water. Then they are covered for a day with sulphurous acid 1 in 5 (20 per cent.), alternatively with hydrochloric acid, 8 per cent., or with 1 in 400 permanganate of potash and afterwards decolourised in a saturated oxalic-acid solution. After all acid has been quite washed away, the sponges are placed in a jar covered with 1 in 20 carbolic acid, where they must remain at least a day, and better a week,

before use. After use the sponges must soak in warm water and be kneaded for a day until all the fibrin of the blood has become fluid and is got rid of, then the above process is repeated. Marine sponges may be boiled in a solution of tannic acid and potash (potassium hydrate 1 part, tannic acid 2 parts, water 100 parts), and so sterilised without being injured, but they are turned black. It is safer, however, to burn all sponges which have come into contact with infected material. One of us, Walsham, never uses anything but sponges, but they are only used once.

2. *Syringes and catheters.*—These tubular instruments require especial care; they must be syringed through immediately after use before they dry. A morphine syringe must be syringed through immediately with 1 in 20 carbolic acid; the newer kinds can be boiled in a steriliser; finally, absolute alcohol should be drawn through the needle to dry it. None of the solution should be allowed to remain in the needle.

Catheters should be syringed through with soap and water, to get rid of oil and mucus; then laid in carbolic acid, 1 in 20, in a tray, for one hour, or wrapped in gauze and sterilised by steam. The common rubber or black catheter can be boiled in a saturated solution of ammonium sulphate. Lycopodium powder will prevent catheters and bougies from sticking together.

3. *Preparation of the patient, and especially the skin of the operation area.*—When time allows, the following general matters should be attended to; when not, as in the case of accidental wounds, the local measures must still be carried out as far as is possible.

(*a*) *General preparation.*—Before any severe operation the patient should go to bed for a day or two, if not already confined there, and be kept on his ordinary food, but not a heavy diet. A full examination should be made, including that of the heart and lungs, the pulse at each wrist, and the urine. His bowels should be moved by an aperient. Generally this is given overnight, and an enema early in the morning. It is often preferable to give the aperient the night but one or early in the day before that of the operation, with the object of not disturbing the patient's rest on the night immediately preceding the day of operation. Sometimes in abdominal cases a course of purgatives is required for several days to overcome constipation. An enema before the operation may consist of a pint of soap and water, with or without the addition of one or two ounces of castor oil. This enema should be returned, but if it shows no signs of acting another may be given, or a tube passed into the rectum for a while, or a large suppository cut out of yellow soap introduced. This failing, the surgeon should be informed, and a handful of wool placed over the anus; or if the operation is on the rectum, it will have to be washed out after dilating the anus. A patient must always be reminded to pass water just before the operation. If from nervousness he cannot

do so, he should be catheterised. This catheterism should be done as a rule in all pelvic cases ; in women with a tumour wedged in the pelvis in which case the bladder is likely to be drawn up, a stiffish catheter will be required, and should be pushed further in than usual.

(*b*) *General cleanliness.*—A patient should, whenever practicable, have a hot bath, with free use of soap, on the afternoon before an operation, and put on clean linen. At the same time the hands and feet should be especially cleaned and the nails pared. To more thoroughly prepare the scrotum and anal region, the patient may sit for an hour in a bath of permanganate of potash. If too weak for a bath (a nurse should keep within earshot of a patient in a hot bath, for fear of syncope), the patient must be washed as far as possible all over whilst lying on a mackintosh sheet. Hairy parts require special attention. After washing and drying the head, the hair should be all drawn through a fine-toothed comb. If lice, nits, or ringworm be present, the hair must be cut short or the head quite shaved, the sores treated, and the scalp wrapped up in a towel or covered with a mackintosh skull-cap. This covering is always required when the operation involves the head or neck, whether the hair is removed or not. In all operations on the genitals the pubic hair should be shaved. In the case of women this should be done by the nurse to avoid any objection by the patient ; it is impossible otherwise to get sufficient cleanliness ; also it is more comfortable for the patient, for otherwise the hairs become matted by blood and discharges, or are caught in bandages. The axilla must be carefully shaved and all the sebaceous material got rid of when operations involve that region, as in removal of the breast. The teeth require to be cleaned, and as far as possible tartar brushed away, and hollow cavities cleared by pledgets of wool soaked in carbolic acid. The patient should remove false teeth and rinse out his mouth just before the operation.

(*c*) *The skin within the area of operation.*—Measures will vary in degree according as the skin is thick and greasy, or thin, as generally in a child, or on the face in the neighbourhood of the eyes and mouth. Thick and greasy skin, after all hair has been shaved off, is softened by hot soap and water, then scrubbed with pledgets of wool soaked in ether, turpentine, or spirit, to get rid of fat ; then with 1 in 20 carbolic acid, or perchloride of mercury 1 in 1,000 in water, or better, with a spirit lotion of biniodide of mercury (spirit ʒj., pot. iodi. gr. ii., hyd. biniodide gr. i.), and twelve hours before the operation it is covered with lint wrung out of carbolic-acid (1 in 40). Crusts of dirt and sweat and lampblack are got rid of by applying boric-acid fomentations, or soaking the part in a boric-acid bath, until the encrustations can be scraped off. Thinner skin, especially that of children, requires gentler usage; after making it apparently quite clean by soap and water, it is wiped

over with 1 in 40 carbolic acid, or 1 in 2,000 perchloride of mercury, and one hour before the operation, lint wrung out of 1 in 40 carbolic acid is applied. The face should simply be well washed and dried, and covered with wet boric-acid lint. The lint-guard should be kept on till the patient is on the operation table. The surgeon, or nurse applying the preliminary dressing, should wash and sterilise the hands after the shaving and washing is complete before antisepticising with the carbolic and spirit lotion.

4. *The hands of the surgeon, of his assistants and nurses.*—The hands of all those engaged in surgery require constant attention. It must become a matter of habit to keep them constantly clean, to pare and trim the nails, and remove all tags of skin daily. Starting from habitually clean hands and nails, it is easy to render them fit for surgical work. The hands and arms to above the elbow are washed in hot soap and water, scrubbed with a nail-brush, swilled in clean water, and plunged into 1 in 40 carbolic acid, or 1 in 2,000 perchloride of mercury; or better, biniodide spirit lotion. Such hands are then sufficiently free from virulent germs as to be fitted to carry through any surgical operation. The skin of such hands is not free from bacteria, but practically experience shows that the organisms remaining in the crevices and ducts do not infect wounds. If the hands have been soiled by any organic matter further measures are required. After the hot soap and water they should be freed from all traces of grease and odour by rubbing with pledgets of gauze soaked in ether, turpentine, or spirit. The specially infected finger may be rubbed with 1 in 20 carbolic acid, or 1 in 500 perchloride of mercury in spirit, and held under 1 in 40 carbolic acid, or 1 in 2,000 perchloride, for a few minutes. Some use instead a solution of permanganate of potash, decolourising the hands with hot saturated oxalic-acid solution.

Gloves have been introduced for wear by surgeons and nurses, but are not likely to come into general use. Rubber gloves serve to protect the hands against foul material and strong antiseptics, in the same way that such gloves are worn at post-mortems. But if at all tight the fingers are numbed; if loose, they are clumsy, and fluid, sweat, and epithelial débris are churned up, so that if pricked this fluid is squirted out into the wound. To take a crucial instance, they cannot be worn whilst the hand is exploring the peritoneal cavity, for nothing can be felt with certainty. Cotton gloves, which can be sterilised by boiling in soda-water, not only deprive the surgeon of the guidance of touch, but being at once soaked through, the surgeon cannot turn and swill his hands in a basin, but must change his gloves. A dozen pairs or more are required at an operation, and time is wasted in changing them. Some surgeons have worn veils to cover the head, face, and beard. A square of aseptic gauze, 80 by 50 cm., three layers thick, has an oval piece cut out of it for the eyes, and is then put over the head and tied round the neck, or the

collar of the coat buttoned over it, and pinned at the back of the head to keep the slit for the eyes in place. This also appears unnecessary. Long beards, like long nails, are unsuitable, and the breath is kept from doing harm by attending to the teeth and nose. Before the operation the surgeon should put on a sterilised linen coat or a mackintosh apron.

5. *Operation room.*—(*a*) In the great majority of hospitals *the operating theatres* have been of late years refurnished or rebuilt, with the object of preventing any chance infection during the operation. The floors, walls and ceilings, and shelves are of marble, tiling, or glass, which can be washed clean, with no corners nor crannies in which dust can collect. Woodwork is dispensed with, as a source of dust, except for doors, which fit closely and have an even surface. All brass and metal work is kept polished. The rooms require to be specially heated to 68° to 70° F., and ventilated often with filtered air, so that a regular temperature of 67° to 70° F. may be maintained, with a frequent change of air. All drains are well trapped. Bowls are to be of polished metal, glass, and china; so also all tables and stools. They are to be cleaned by soap and water, boiling soda-water, and 1 in 40 carbolic acid. Adjacent to the theatre are rooms for washing hands, an anæsthetising room, a nurses' preparation and sterilising room, and a store-room. There being an ample supply of boiled water, this may be passed through a pressure filter as an additional precaution. An operating room should be lighted through a north window, and be fitted with an electric light, the current being also adapted to a motor and for the cautery. Operating tables are made with various objects; one form may be raised on to rubber wheels, and so the patient taken from and to his bed; some have arm and leg flaps, and levers or screws for raising the pelvis or shoulders. Stationary tables admit of adaptations for special positions—lithotomy, elevation of the pelvis (Trendelenburg), also of being heated by hot water.

(*b*) *Operations in private* do perfectly well when the house is satisfactory from a general sanitary point of view. If time admits the room is prepared by clearing it entirely of furniture, hangings, and pictures; scrubbing the floor and doors and windows, seeing that these fit for opening and closing properly; that the chimney does not smoke, and that no drains or sinks open near. The room should be opened to fresh air and sunlight for a day or so. Then the heating and ventilation is tested, so that the temperature can be kept day and night about 65° F., and there should be for the patient at least 1,500 cubic feet of air space, and so ventilated that the air can be changed at least every hour. For the operation a strong narrow table should be placed near the window and covered with several layers of blanket and a mackintosh to avoid bruising and pressure, *e.g.*, on the musculo-spiral nerve. Three or four occasional tables are covered with sterilised towels. Meat or pie dishes, basins,

large and small, and jugs, several of each, are collected, scrubbed with soap and hot soda-water, scalded out with boiling water, or boiled for twenty minutes in a copper or clean fish-kettle, or rinsed with 1 in 20 carbolic acid and then covered by towels from dust. Several gallons of water are prepared by boiling for half an hour, and if it has to stand some hours boric acid is added. A dozen or two of clean towels are obtained, and some are sterilised as mentioned above. A narrow bed is prepared with a firm, smooth horse-hair mattress. Under the patient is laid a mackintosh sheet covered by another of linen. A blanket is made hot before the fire ready to wrap the patient in after the operation; also hot-water bottles must be filled by the time the operation is ended and put into the bed, but must be separated by a blanket from the patient, or a troublesome burn may be easily caused in a weak subject during unconsciousness.

An urgent operation, a Cæsarean section, or strangulated hernia has often to be done under unfavourable circumstances. It is well in such a case to disturb dust and dirt as little as possible by operating in the middle of the room, and leaving the pictures and furniture by the walls undisturbed, whilst sprinkling water over the floor to lay the dust. Chlorinated lime should be thrown over any adjacent refuse heap or down the cesspool. In operating at night common glass lamps are most dangerous; several candles stuck in various positions avoid shadows. Carriage and bicycle lamps or a portable electric light prove serviceable. The inflammable material used, benzine, ether, spirit, collodion, should always be kept away from naked light.

6. *The patient is placed on the table* and well covered up elsewhere than over the part to be operated upon, to protect him from loss of heat. The legs and feet are kept covered with stockings; babies are swathed in wool. In some countries the patient is stripped, placed on a heated table, and the temperature of the room kept up to 80° F., but the heat is most oppressive, and other objections to these measures are obvious. Then the patient is suitably anæsthetised. When this is done the operation area is isolated by mackintosh sheets covered by carbolised or sterilised towels. The carbolised lint-guard is not taken off until the incision is about to be made, and before the incision a final sponge over with biniodide spirit lotion should be given. By arrangement of mackintosh sheets, etc., the fluids used overflow and drain off into a pail on the floor. The sponges and clamp forceps must first be counted, and the number put down on a slate. This preliminary is essential in all operations on the abdomen. Any which fall on the floor or into pails must be put on one side, and all re-counted just before the wound is sutured. If a sponge be cut into two during the operation the fact must be noted, or the re-count might lead to a sponge being left behind. All objects handed to

the surgeon by assistants and nurses should, as far as possible, be held on sterilised forceps or towels.

7. *Ligatures and sutures.* — Surgeons are not yet agreed on these things. (*a*) *Closely-twisted silk* and *Chinese twist* in various sizes will serve all purposes, *e.g.*, No. 000 for fine intestinal sutures and the ligature of small vessels, No. 0 or 1 for ligaturing vessels requiring strain, No. 4 or 5 for stout pedicles and deep interrupted sutures. A clean skein is wound on a glass reel, which may then be boiled in a soda solution, although this may lead in the finer kinds to fragility by untwisting. Then the reel is placed in a wide-mouthed stoppered bottle containing 1 in 20 carbolic acid. The free end is seized with forceps, drawn out, and the length cut off without handling the reel. Floss silk can be used for large pedicles. The one objection to silk is that occasionally the knot is not absorbed, but causes a troublesome sinus, through which it is ultimately discharged.

(*b*) *Catgut* is prepared by first allowing animals' intestines to partly rot, then twisting up, by which many virulent organisms are included. These have to be destroyed, and innumerable methods have been described, very many of which are successful as a rule, but not always. Occasionally a virulent or even fatal suppuration occurs from the development of streptococci, etc., around the ligature-knot. No method has yet been entirely successful in disinfecting the catgut, as proved by the continual appearance of fresh proposals. Hence many never use catgut. Those who do so, prefer it for its readiness of absorption after serving its purpose. The brown catgut must be kept sealed until used, and it is dangerous to keep a once-opened bottle. It must be placed only for a minute or so in carbolic-acid lotion, or it will be too much softened. When treated with chromic acid it is kept dry until use, when it is placed in 1 in 20 carbolic acid for five minutes; it takes longer to be absorbed. Of the more certain methods of sterilising catgut may be mentioned the placing of chromicised catgut in cumol or xylol in a metal vessel with a screwed-on top, and then boiling the metal vessel in a steriliser, afterwards transferring the catgut to 1 in 20 carbolised spirit.

(*c*) *Linen thread*, as used in a sewing machine, is thoroughly strong and can be boiled in a steriliser, but is probably not absorbed at all. *Hempen ligatures* were formerly in vogue; lately they have been passed through celloidin, to give them a smooth surface. They are likewise probably never absorbed.

(*d*) The split *tendons* from the tail of *kangaroos*, or those from the ligamentum nuchæ of the *reindeer*, have this great advantage over catgut, that when taken from a healthy freshly-killed animal they are uncontaminated by germs. They are prepared and preserved dry, but a day or more before use are placed in 1 in 20 carbolic acid. By splitting the tendons, various sizes are obtained. They are most useful for the ligature of vessels in continuity, ligaturing

varicose veins and varicocele, also for deep-buried sutures in the abdominal wall, etc., where they are absorbed in a month or six weeks.

(*e*) *Silkworm* or *fishing-gut sutures* are of the same material used for fishing-lines, but they are too rigid for tying vessels. Silkworms are specially fed, and being free from disease are killed, twisted up, and drawn out. These strands are excellent as interrupted skin

Fig. 67.—Surgical needles and hair-lip pin.

sutures. As buried sutures they remain quite unabsorbed, and in some cases set up irritation.

(*f*) *Silver wire* is used for sutures, its great value being that no germs adhere to its polished surface. It is employed for skin sutures where there is much tension, and silver wire mixed with lead to render it less brittle for bone sutures. Some surgeons bury it in the abdominal wall in hernia and other operations, trusting that it will become permanently encysted, but not infrequently it becomes so troublesome as to require removal.

(*g*) *Horsehair* is likewise naturally free from germs, and is therefore admirable for interrupted skin sutures whenever there is not much tension. If buried it remains unabsorbed.

For the application of the ligature, see p. 212.

D. **Suture of wounds.**—*Surgical needles* of steel, straight, curved

Fig. 68.—Needle fixed in a solid metal handle.

or semicircular (see Fig. 67), when used for perforating skin must have the pointed end triangular, spear-shaped, or chisel-shaped (Hagedorn's). Pins are rarely used except for the lip (Fig. 67). The round sewing-needle cannot be passed through skin, but is suitable for the deeper and softer structures and mucous membranes, as the needle makes only a minute round hole. Fine sewing-needles should have a split eye to facilitate threading, *e.g.*, with No. 000 Chinese twist silk for intestinal suture. There are many kinds of needle-holders, but skilful fingers are best, or when necessary clamp forceps can be used. Needles are also fixed in solid metal handles

(Fig. 68); the finest kinds are used for cleft palate, etc., the stronger for hernia, and for transfixing pedicles. A most useful needle for passing skin sutures is that known as Barker's.

Unless there is ample assistance, needles should be threaded beforehand to avoid delay.

Sutures may be inserted by the continuous or interrupted methods.

(*a*) *Continuous.*—(1) Simple continuous suture: The sutures are

Fig. 69.—A simple continuous suture, which at the end is fixed by passing the needle through a loop which, when drawn tight, will form a slip-knot.

passed through the wound at right angles to the line of union, which above the surface they cross obliquely.

(2) A button-hole or looped continuous suture (Fig. 70): The needle after each puncture being passed through the loop, crosses the line of union transversely. This suture is capable of bearing some tension.

(3) A glover's in-and-out suture (Fig. 71): The suture only pierces the line of union at right angles, but does not cross it; on

Fig. 70.—Continuous button-hole suture. The suture can be finished by drawing the double thread on the needle tight without allowing the single free end to be drawn through the last puncture; then the single free end is tied with the double thread on the needle.

being drawn tight the edges of the wound tend to pout. Thus the suture can be used to turn mucous membrane inwards or skin outwards.

Continuous sutures can be fixed at any point by making a back stitch, or are tied at the end as shown in Figs. 69 and 70.

(*b*) *Interrupted suture.*—(1) Simple interrupted suture, tied by reef knots (see Fig. 72, 1 to 6); or if there is much strain a second loop is made in the first hitch, the surgeon's knot (see Fig. 74).

(2) Quilted suture has several variations. A double-threaded suture is passed (as seen in Fig. 73) twice in and out on each side of and at right angles to the line of union. On drawing the sutures

Fig. 71.—Glover's suture.

tight, the edges of the wound are turned in, hence its use as a sero-muscular suture in intestinal surgery, by which the mucous membrane

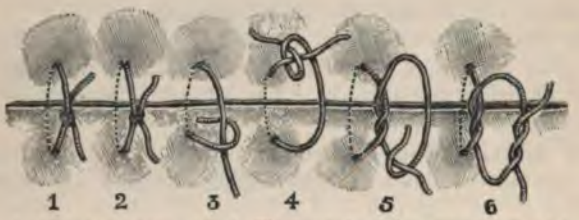


Fig. 72.—Interrupted suture. 1 to 6. The knots in various stages. 3 and 4. The first hitch, which can be drawn so that the knot lies to one side of the line of union.

is turned in. Other forms are used in Macewen's operation for hernia, in tendon anastomosis, etc.

In uniting a wound, the suturing may be :

(i.) Cutaneous. Continuous or interrupted, as described above, removed after a week or so by cutting to one side of the knot.

Fig. 73.—Quilted or Halsted's suture.

(ii.) Intra-dermic or sub-dermic. The suture is passed in and out and from side to side, through the deeper layers of the skin, without coming to the surface, except at each end of the wound, where the suture end is brought out and is fixed there by tying it to a pledget of gauze, or passed through a button and fixed by a split shot, etc. The suture is removed by cutting through one end and pulling on the other.

(iii.) Deep interrupted sutures pass through all the layers (Fig. 74) of the wound.

(iv.) For suturing by stages buried sutures are now largely used in all deep wounds where muscles tend to retract; in the case of the abdominal wall, peritoneum is united to peritoneum, muscle to muscle, aponeurosis to aponeurosis, skin to skin (Fig. 75).

Fig. 74.—Deep interrupted suture, passed through all the layers of a wound (*e.g.*, the abdominal wall, 1, skin; 2, muscle; 3, peritoneum), and tied by a surgeon's knot, *i.e.*, by making a second loop in the first hitch.

(v.) Primary suturing: The sutures inserted and drawn tight at the end of the operation is the rule.

(vi.) Secondary suturing is suitable for septic wounds and suppurating cavities, which are first kept open until rendered healthy by dressing and then united by suture.

E. **General course of an operation.**—The surgeon, making the skin a little tense between the thumb and fingers of his left hand, and holding the knife in his right hand as a violin-bow,

Fig. 75.—Suturing by stages. 1. Skin sutured to skin. 2. Muscles sutured to muscles. 3. Peritoneum sutured to peritoneum. Either continuous or interrupted sutures are used.

dinner-knife, or pen, according to taste, points it almost vertically downwards to puncture the skin, then slopes the handle and draws a steady cut through the skin to end by again raising the handle almost to the vertical. The edges being retracted (Fig. 76), another drawing cut is made through the deep fascia. Arriving at muscle, the fibres are divided as far as possible longitudinally. Many—we amongst the number—hold it much better to separate the fibres

bluntly rather than to cut them across and so leave a permanent weak gap. The deviation from the principle of cutting cleanly does not seem to do harm in the case of muscle in an aseptic wound. Arriving in the neighbourhood of an important structure, an artery-sheath or the peritoneum, the surgeon proceeds cautiously by picking up the structure with dissecting forceps before dividing. He will very rarely require to use a director, which may do harm by being pushed into unseen structures. Vessels that bleed are seized with clamp forceps, which mostly hang over the edges of the wound until all cutting is finished, when ligatures are applied over the forceps. A wound may be readily enlarged by using scissors whenever the under blade can be guarded by the finger. A wound need only be sponged until the end of an operation, when it may be swilled with boiled water to get rid of blood-clot, and then mopped dry and sutured. In the case, however, of an accidental wound, presumably or obviously infected, all pockets must be laid open, avoiding important structures, blood-clot and foreign débris cleared out, and bleeding arrested. Then the whole area is well scrubbed out with

Fig. 76.—Retractor.

1 in 20 or 1 in 40 carbolic acid, or in some cases with the pure acid, all of which is swilled away with water.

Drainage.—An aseptic wound in which there is no cavity for blood to collect in requires no drainage. Most superficial wounds, also wounds of the abdominal wall, are completely sutured. An accidental wound, however well disinfected, also an operation wound, which when closed has a cavity in which blood may collect, is better drained for a few days, by inserting a strip of iodoform gauze or a rubber tube perforated by cutting a number of side holes, which can often be removed at the first dressing. A cavity being filled with a long strip of gauze, a little may be withdrawn every day for a week or ten days, during which the wall of the cavity is contracting, whilst discharges are taken up and prevented from being absorbed. Even for draining suppurating wounds and cavities, drainage-tubes are not so much used. Generally, it is better to make a wide opening, and fill the whole with iodoform gauze, which is changed every day or two until the whole surface is lined by healthy granulations, when healing may sometimes be expedited by applying secondary sutures, so as to draw the granulating surfaces together. The withdrawal of the gauze is facilitated and much pain avoided by soaking it before removal with peroxide of hydrogen. Some wounds are sutured as regards the deeper part, but the skin is partly left open, lest, as in the case of wounds of the bladder, œsophagus or larynx, leakage

may occur from within, and septic infection spread widely beneath the skin.

Before use, drainage-tubes are kept in carbolic-acid lotion (1 in 20). Lest a tube be lost in a cavity, *e.g.*, an empyema, it should be fixed to the dressings by a strand of silk or by a safety-pin. A counter-opening sometimes gives better drainage. It is made by pushing sinus forceps through the bottom of the cavity towards the skin avoiding important structures, cutting down upon the forceps, seizing with them the tube and drawing it into the cavity through the counter-opening. A tube should be removed as soon as possible to avoid the formation of a sinus.

Tough glass tubes are used for draining the pelvis through the hypogastrium, and when a piece of rubber tubing is joined to the outer end, the fluid may be sucked over into a vessel under the bed. (See also Paul's tubes, under *Colotomy*.)

Dressings should allow of (1) the protection of the wound against infection; (2) the absorption of discharges from the wound; (3) a ready evaporation and drying so as to produce a hard cake, by which drying the growth of organisms is largely prevented both on the surface of the wound and in the interior of the dressings. Antiseptic dressings avoid frequent changing of dressings, lasting a week or more, and so save disturbance of the patient and his wound. Aseptic dressings, whilst cheaper in large quantities and less liable to irritate, must be changed more frequently, *e.g.*, every two days or so. Only when likely to stick, *e.g.*, to the intestinal surface or to skin-grafts, is a layer of protective glazed material laid between the wound and the dressing. In some cases, *e.g.*, near the genitals and the mouth, also where the end of a drain is brought out through the dressings, the dressing is protected from outside contamination by protective, the glazed surface turned outwards. In the case of fomentations the protective is now used to keep in moisture, the glazed surface being turned inwards. In all other cases it is most desirable that moisture in the dressings should be allowed to dry as much as possible.

Bandages are best made of elastic flannel "domet"; cotton and linen bandages are less elastic. A perforated rubber bandage can be used again after being cleaned; others should be burnt, not re-employed. A bandage aims at putting equal pressure on the wound so as to keep it at rest and protected against sudden movements. It is applied as a spiral, figure-of-eight, or spica bandage. The first application should be firm to check oozing, yet without causing undue constriction. In the limbs this is avoided by bandaging from the extremities upwards and by elevation. Usually, after twelve hours a tight bandage may be eased to the comfort of the patient. A roller bandage is generally the most convenient form for the limbs; for the trunk a many-tailed is of advantage; for the perineum a T-bandage. Triangular handkerchiefs are convenient for temporary use, especially

to the head, and are handy for slings. A sling is also made from a strip of bandage by throwing a clove-hitch.

F. **After-treatment.**—Until the patient has recovered from the anæsthetic a nurse should stay by his side. Afterwards patients require watching against unforeseen wound complications, such as hæmorrhage, sudden impulses, especially in children and young people; also to prevent them from getting out of bed when half awake.

(*a*) The *temperature*, the *pulse-rate*, and the *respiration* should be regularly recorded, also the *motions* and their character, *urine* and its quantity, sleep, and incidents such as *vomiting*, *hiccough*, *passage of flatus* up or down, in all important cases.

The *temperature* will show by its normal character that nothing important is amiss; by considerable elevation that there is septic intoxication, septicæmia, or pneumonia; by being below the normal that the patient is suffering from shock, is weak, or occasionally it may point to suppuration in the brain or chest. The rate of the *pulse* by not exceeding 100 with little elevation of temperature probably indicates only a slight absorption of broken-down material; by rising above 100 without any corresponding elevation of temperature, that the patient is weak. If there is a rapid pulse with a temperature not above 100 to 101, or even subnormal, there are indications of septic inflammation of the asthenic type, and if this is combined with leucocytosis, there is also deep-seated suppuration. An increased *rate of respiration* will give general information as to the state of the patient's lungs, *e.g.*, to the nurse, also of pulmonary embolism suddenly supervening, and distinguish those cases of pneumonia, which commence with abdominal pain and tenderness. The *urine* may be small in amount, highly pigmented, following loss of fluid by vomiting and sweating, also from absorption of blood-clot; even there may be some temporary albuminuria. Definite albuminuria is set up by septicæmia.

(*b*) *Diet.*—As a rule, in an ordinary case a patient should not take any food until nausea and vomiting have passed; it may be for twenty-four hours. Meanwhile he may sip hot water, iced water, lemon drink or barley-water just to keep off thirst. Then he may try a little hot tea, milk and water, soda-water and milk, or clear broth. Generally the patient should as soon as possible return to an ordinary light diet, for a healthy patient on a fluid diet will suffer from flatus, etc. In a weak patient the recovery of the power of digestion will be slower; for such a fluid diet, then fish or chicken, is desirable; his appetite may outrun his powers of digestion and require to be checked, or it may have to be tempted by special cookery.

Young children, old people, and exhausted patients cannot be kept for long without food. Young children will generally take quite well as soon as they have awoke from the anæsthetic. Old and exhausted patients often suffer but little from vomiting, especially when the

operation has not involved the abdomen, and will often be able to take broth or milk with soda-water within four hours of the operation.

Exhausted patients, and especially severe abdominal cases, should be given immediately after the operation a nutrient enema of milk or beef essence, or white of egg, with or without the addition of ℥ss. to ℥j. of brandy; a meat suppository may be given at the same time. This may be continued every three or four hours until the patient can take well by the mouth. Every twenty-four hours the patient's rectum must be washed out by a cleansing enema.

(*c*) *Alcohol* is not given as a rule. In old people and others accustomed to take alcohol in moderation, no harm follows a return to their usual habits. It is not, however, needed by healthy persons during convalescence. In weak and exhausted patients alcohol is regarded as a supplement to an otherwise deficient intake of food. But especially in young people, *e.g.*, suffering from tuberculous disease, etc., the alcohol should not be continued much longer than a month, but the patient as soon as possible be sent to the country or seaside. But when there is a septic condition with a rapid, feeble pulse, dry tongue and high temperature, alcohol must be given freely, *e.g.*, a pint of champagne or four ounces or more of brandy daily.

(*d*) *Bowels.*—The patient will be rendered comfortable by a movement of the bowels about twenty-four hours after the operation. There is no harm in this; on the contrary, in intestinal cases, it is believed to tend against inflammatory complications, and in rectal operations, such as piles, an early motion is thought by some to be better than a delay until scybala form. Few now give opium to confine the bowels; it is a mistake to think that confinement of the bowels is synonymous with arrest of peristaltic movements. They continue to occur irregularly and cause the patient uncomfortable and griping sensations, an elevation of temperature and abdominal pain and tenderness, all of which disappear when the bowels are moved. To obtain this end, liquorice powder, cascara, or calomel (grs. iii. to v.) may be given, with an enema some hours after; or a seidlitz powder, or a calomel and colocynth pill. Where it is difficult for the patient to keep anything down, a grain of calomel or a drachm of sulphate of magnesia in hot water may be administered every hour until the bowels are moved. Or one may depend upon enemata alone, a glycerine enema or suppository, a soap enema, to which, if there is flatus, half an ounce of turpentine is added, or two ounces of castor oil. Sulphate of magnesia, either by the mouth or in double doses per rectum, should be selected when the urine is deficient; at the same time the functions of the skin are aided by hot sponging.

(*e*) *Sleep.*—For sleep after operation, especially when there is some pain, injections of morphine are best, and even if sleep does not follow, the patient will be calmed, and this will last well into the next day. The morphine may be repeated for a few days, but should not

be continued but replaced by some hynoptic, bromide of potash, chloral, sulphonal, hyoscin, trional, chlorotone, etc.

Varieties of Wounds.

Wounds may be divided into: (A) open, and (B) subcutaneous.

A. **Varieties of open wounds.**—Open wounds are divided into incised, lacerated, contused, punctured, gunshot, and poisoned.

(1) *Incised wounds* are such as have their edges evenly divided and their surfaces smoothly cut. They are usually inflicted by sharp instruments, and are those commonly made by the surgeon in operating. The danger which is particularly liable to attend them is hæmorrhage. Healing is generally accomplished by the first intention, provided the proper means are employed. *Treatment.*—What has been said under the treatment of wounds generally, applies especially to this variety.

(2) *Lacerated wounds* are those in which the tissues forming the surface and edges of the wound are irregularly torn. They are commonly caused by street or railway accidents, machinery, or by the goring and bites of animals. There is usually but little hæmorrhage, in consequence of the vessels being torn rather than cut across. The chief dangers are profuse suppuration, sloughing and extensive scarring, septic infection, erysipelas, tetanus. Healing is generally accomplished by the second intention, the dead portions of the lacerated tissues being first thrown off by ulceration in the way described under *Gangrene.* In some situations and under favourable conditions, however, a large part of the wound may heal by the first intention. *Treatment.*—Special attention should be paid to the cleansing of the wound and establishing a free drain. The lacerated and displaced muscles, etc., are fitted into position and sutured; nothing should be cut away unless it is obviously dead. Sutures should not as a rule be applied at first, but the wound should be dressed by filling it with iodoform gauze, and later when covered by granulations secondary sutures may be used.

(3) *Contused wounds* are those in which the tissues forming the surface and edges are extensively bruised. They are usually made with blunt instruments or with such agents as distribute the force over a large surface. There is commonly considerable extravasation of blood amongst the bruised tissues, though usually but little external hæmorrhage. The chief danger is from the septic infection of the blood-clot through the skin and of secondary hæmorrhage on the separation of the sloughs. A combination of laceration and contusion is frequently present. Healing is generally accomplished by the second intention. The *treatment* is similar to that of lacerated wounds. Any portions of skin which have not lost their vitality should be preserved, especially if the wound involves the scalp or face.

(4) *Punctured wounds* are those in which the depth is much greater

than the breadth. They are usually produced by sharp-pointed instruments, bayonet or sword thrusts, and stabs. The chief dangers are hæmorrhage, penetration of important cavities, as the thorax, abdomen, or a joint, injury of a large blood-vessel or nerve, and subsequently deep suppuration in consequence of sepsis and the retention of the discharges in the deep portion of the wound. Punctured wounds by a clean instrument, uncomplicated by injury to an important tissue, heal by first intention. For such the external wound may be closed with a collodion gauze dressing. Punctured wounds, however, usually unite by the second intention, owing to the difficulty of keeping the deeper parts of the wound in contact and of preventing sepsis and the collecting of serum and later of pus. *Treatment.*—The wound should be syringed out with carbolic lotion (1 in 20), and it had better be plugged with antiseptic gauze, or prevented from closing by a drain-tube inserted just through the external opening. If there is severe arterial hæmorrhage which cannot be controlled by carefully applied pressure, or evidence of a large nerve having been severed, the wound must be converted into an incised one, and the bleeding vessel or injured nerve treated in the way described under *Wounds of Arteries, Veins, Nerves, etc.* For the special treatment required where a joint or a visceral cavity has been penetrated, see *Injuries of Regions.*

(5) *Gunshot wounds* may be punctured or even incised wounds, particularly when due to a modern bullet, or contused or lacerated wounds, especially when the result of explosions and shell wounds. There are a number of varying conditions connected with the gunshot wounds themselves, also with the surrounding circumstances at the time of and following the injury.

A gunshot injury may result (1) in gunpowder staining, fragments of charcoal lodged in the skin of the face; (2) in small shot and slug wounds, by which the eye may be injured, or the small shot be lodged in the skin and cause trouble to a sensitive part; (3) from explosions, charges of small shot at close quarters, and shell wounds causing extensive laceration; (4) from large bullet wounds combining a puncture with more or less lacerations; (5) from pistol bullets and small-calibre rifle bullets of high velocity, causing simple punctured wounds.

Amongst the variations in surrounding circumstances are: (1) Clothing, septic material, etc., carried into the wound at the time of injury. This complication is absent, or only occasional, with modern rifle and pistol bullets. (2) Hæmorrhage, owing to the patient's struggles and exertions, or the lack of first aid after the wounding. (3) Septic material introduced by the wound remaining uncovered, but especially by probing and fingering of wounds without antiseptic precautions. (4) Delay in operating upon a patient or difficulties in treatment afterwards, especially in war time, less often in civil practice.

The important complications of a gunshot wound are: (*a*) Septic inflammation; (*b*) injury done to deeper parts, which is more or less concealed; (*c*) the presence of a foreign body, a retained bullet, a fragment of shell.

A gunshot wound is immediately fatal either from hæmorrhage or from injury to the central nervous system directly or reflexly. A bullet of high velocity cuts cleanly across an artery, which may then bleed freely, either externally or into a cavity of the body; or if the vessel only bleeds into the surrounding connective tissue through a small hole, a traumatic aneurysm results. Practically, all injuries to the base of the brain and the upper end of the spinal cord are fatal. Injuries affecting only the cortex of the brain and the lower part of the spinal cord need not be so, but come under surgical treatment. Fatal cases of shock also occur by reflex action on the central nervous system, in gunshot wounds of the face, neck, thorax or abdomen.

When a *bullet of small calibre* enters the skin it makes a small triangular puncture like an exaggerated leech-bite, which after healing only leaves a minute depressed circular scar. The wound of exit may be but little larger, unless the bullet drives bone in front of it. In passing through soft parts it may be said to penetrate like a needle, mainly pushing tissue to one side. It may make but a small round hole through an artery or pass through a nerve by splitting it; when meeting with a bone the result varies, according to the velocity and the resistance and perhaps its rotation, for some bullets bore through the bone like an auger. When meeting with hard bone there is often most extensive splintering and displacement of fragments in all directions. A bullet entering the skull may simply traverse it, leaving only a narrow bruised track behind; in other cases it acts explosively, as does a bullet on being fired into a sealed tin containing semi-fluid material, the skull-cap and brain are blown out, or the skull and brain are reduced to a pulp beneath the intact scalp.

Bullet injuries of the brain, thorax, and abdomen will be separately referred to. The general line of treatment to be observed is not to touch the wound until it can be done antiseptically, but simply to apply dry dressing, to which may be added an antiseptic powder or paste. When it can be done thoroughly the skin is carefully cleaned around, but the wound is neither probed nor syringed, but an expectant treatment adopted, except that, under all circumstances in cases of fracture of the skull, and in pistol-bullet wounds of the abdomen in civil practice, an immediate operation is necessary.

A *large calibre bullet* of slow velocity causes a wound of entrance, which is followed by more or less extravasation of blood around and later perhaps by sloughing. Its track is marked by great laceration of soft parts, but it is more easily stopped, only smashing bones at close

quarters, when an extensive compound comminuted fracture results. If it escapes, the wound of exit is larger and more lacerated than the wound of entrance, and attended with more extravasation of blood. It is most important that such a wound should not be touched until this can be done antiseptically. Hæmorrhage is controlled by direct pressure on the temporary dressing applied to the wound. But no attempt is to be made to remove foreign material or to seek for the source of the hæmorrhage, until this can be done with all care. Then, after cleansing the skin around, and with antiseptic hands and instruments, the wound is well syringed out, bullets, splinters, fragments of clothing, etc., removed. This may necessitate enlarging the wound of entrance or of exit. After rendering the wound aseptic and arresting hæmorrhage, it is partly filled with iodoform gauze strips, partly sutured, according to circumstances. *Shell* and *explosive wounds* are treated on the same lines; the extensive compound comminuted fractures of limbs generally call for amputation as soon as the primary shock has passed off. When the head, thorax or abdomen are extensively injured, the results are mostly fatal.

Small shot and powder grains have to be picked out with as little cutting as possible, *e.g.*, by using eye instruments.

(6) *Infected, septic or poisoned wounds.—Post-mortem wounds.*—Wounds received in the course of dissecting well-preserved bodies rarely give rise to trouble, unless it be to chronic warts, which are of a tuberculous nature. Post-mortem wounds owe their virulence to inoculation with infective micro-organisms which are capable of multiplying in the tissues or even in the blood, and so setting up true infective inflammation and blood-poisoning. These micro-organisms are crowded out or replaced, as decomposition of the corpse sets in, by the bacteria of putrefaction. Hence the longer the body has been kept, the less dangerous the wound, as these bacteria are merely capable of inducing a local inflammation, and not a true infective process. The most dangerous wounds are those received whilst examining bodies in which death has recently resulted from septicæmia, pyæmia, diffuse or puerperal peritonitis, and erysipelas. The effects of a wound received in dissection, or in post-mortem inspection, will depend in some degree upon the health of the operator; if strong and vigorous he is better able to resist the toxic effects than when debilitated by prolonged study or work in a hospital ward. On the other hand, persons acclimatised to the dissecting or post-mortem room are said to become less liable to be affected than those who have but recently been engaged there. But it is a great mistake to put any reliance on this statement.

The *signs*, as might be expected from what has been said above, vary considerably, depending, as they do, upon the nature of the poison received from the corpse and the previous state of the

operator's health. Thus: 1. A pustule may form at the seat of inoculation, and, after breaking and scabbing, leave a raised, indolent, painful red sore, which may exist for months, in spite of treatment. 2. The scratch or wound may become inflamed, the superficial and perhaps the deep lymphatics implicated, and the axillary glands enlarged and painful, this condition being attended by sharp constitutional disturbance, often preceded by a rigor. Suppuration generally occurs at the seat of inoculation, and sometimes also in the axillary glands. The prognosis is usually good. 3. With or without the local signs of the preceding form, in a few hours severe constitutional symptoms may set in, beginning with a rigor, and rapidly assume a typhoid character. Diffuse suppuration occurs in the axillary glands, and may spread to the neck and side of the chest. The prognosis is very unfavourable, the patient often dying in from one to three weeks, or only recovering after a tedious convalescence, and then, probably, with a broken constitution. 4. Diffuse cellular, or cellulo-cutaneous erysipelas may be set up at the seat of inoculation, attended with the usual constitutional symptoms of these affections, and may rapidly spread up the limb and terminate in gangrene and death. The axillary glands in this form are not usually affected. 5. In addition to the local suppuration, a pyæmic state, with the formation of metastatic abscesses in various tissues and organs, sometimes occurs.

Treatment.—Immediately on its infliction the wound should be squeezed, and cleansed by a stream of cold water, and bleeding encouraged and absorption prevented by tightly binding the part above the wound. Where the corpse is recent and death is known to be the result of some infective disease, the wound should be washed in strong carbolic or corrosive sublimate lotion (some recommend its cauterisation with pure carbolic acid, caustic potash, or nitrate of silver), and then dressed and protected from further infection. If a wart or indolent sore form, it should be destroyed by nitrate of silver, acid nitrate of mercury, or other caustic, and the patient's health improved by tonics and change of air. Immediately on the first signs of an infective inflammation, the patient should be put under nitrous oxide gas, the wound scraped out, pure carbolic rubbed in, and carbolic acid 1 in 20 injected subcutaneously around. Hot boric-acid fomentations or baths are used, and any abscess that may form in the axilla, or elsewhere, opened early; indeed, if there is much tension or brawniness of the parts, incisions should be made before pus has formed. The bowels in the meantime should be cleared by a brisk purge, and the strength supported by nourishment and stimulants. If spreading gangrene supervenes, amputation as far as possible from the spreading edge should be at once performed, and if it is due to streptococci the antitoxin should be administered, also quinine in 5 gr. doses every three hours until quinism appears.

Stings of insects sometimes cause troublesome local inflammation, which may occasionally assume a diffuse and septic character, and where a large extent of surface is stung, as by a swarm of bees, may be attended with symptoms of severe depression. Stings of the throat occasionally occur from swallowing a wasp, and are liable to be followed by œdematous laryngitis. Flies, it would appear, may sometimes be the carriers of infection from feeding on putrefying material. Thus, the poison of septicæmia, erysipelas, cellulitis, anthrax, etc., may be inoculated in this way. *Treatment.*—The application of ammonia will at once relieve pain. Where there is severe depression, ammonia (sp. ammoniæ aromat. ʒss., not liq. ammoniæ) or alcohol must be administered hypodermically. Scarification, intubation of the glottis, or even laryngotomy, may become necessary in severe stings of the throat.

Snake-bites.—The bites of poisonous snakes, other than the adder, are fortunately rare in this country. The bite of the common adder is seldom fatal. It is attended with much collapse, nausea or vomiting, great pain in the part, swelling of the affected member, subsequent discoloration from blood extravasation, and occasionally inflammation and suppuration. For an account of the more serious symptoms attending the bite of the cobra and other venomous serpents of tropical countries, a larger work must be consulted. The *treatment* consists in squeezing, cupping, or sucking the part where practicable, applying a bandage tightly above the bite to prevent absorption of the poison, and the internal administration of stimulants. For cobra-bites gunpowder may be rubbed in and ignited, or a burning match used as a cautery, or the bitten part may be excised. Recently an antitoxic serum has been prepared from immunised animals by Calmette and Fraser which, if at hand, should certainly be used.

B. **Subcutaneous wounds.**—A wound, whether it be of the connective tissue, bone, muscle, tendon, or other structure, is said to be subcutaneous when the skin or mucous membrane remains intact, or when only a small puncture by a tenotome has been made. As long as the skin or mucous membrane covering the wounded part is unbroken, septic processes are prevented from entering, so that these wounds are attended by but little, if any, constitutional disturbance. But if there is much blood extravasation, they may become infected through the circulation.

Contusions are subcutaneous wounds, occasioned by a crushing, pulping or tearing of the tissues, combined with extravasation of blood consequent upon the rupture of the capillaries and smaller vessels of the part. In their slighter forms they constitute the common injury known as a *bruise*. The effused blood generally makes its way in the connective-tissue planes towards the skin, giving rise to the characteristic purplish-black appearance, and, as it later breaks down and becomes absorbed, to a change of colours

from bluish-black through dark red to yellowish-green. In severe cases the cuticle is raised into bullæ by the effusion of blood-stained serum beneath it. These bullæ, together with the black colour of the part, may occasion a close resemblance to gangrene, from which, however, a contusion may be distinguished by there being no loss of heat or of sensation in the part, and by the bullæ being fixed, and not changing their position on pressure as in gangrene. In very severe and extensive contusions, however, the tissues may be so injured as to lose their vitality, and gangrene actually ensue; whilst in other instances inflammation and suppuration may occur. When the contusion is localised, blood to a considerable amount may be poured out at the injured spot, forming a fluctuating swelling known as a *hæmatoma*. Contusions of muscle, bone, blood-vessels, and nerves, and contusions of the viscera, are considered separately under *Injuries of Special Tissues and Organs*.

Treatment.—Beyond placing the part at rest, and applying an evaporating or a spirit lotion, nothing more as a rule is required as the extravasated blood presses upon the injured vessels, and so prevents further hæmorrhage. Should a hæmatoma form, it should on no account be opened, as the blood will usually become absorbed; whilst, if air be admitted, suppuration will probably ensue. Aspiration, however, when the hæmatoma is very large, may occasionally be done with advantage. If suppuration occurs a free incision should be made, all the blood turned out, and the cavity filled with gauze. The fluid may remain unabsorbed, and being surrounded by inflammatory tissue form a cyst.

Diseases of cicatrices.—The cicatrices left on the healing of a wound are liable to certain affections which may be enumerated as:—1, painful cicatrix, due to involvement of the nerve-endings in the scar tissue or pressure of the scar on the bulbous end of a divided nerve; 2, depressed or contracted cicatrix, often met with after burns, tuberculosis, and syphilitic ulceration, due to the adhesion of the scar to the underlying structures or to excessive contraction; 3, warty cicatrix; 4, thin cicatrix; 5, ulceration; 6, keloid; 7, epithelioma, and 8, more rarely sarcoma.

Keloid is the name given to hypertrophied scars and puckered scar-like tumours of the skin, about which little is yet known, except that histologically they consist of vascular scar tissue, not distinguishable, however, in many cases from fibro-sarcoma. Further difficulty has arisen from an attempt to define "true keloid" as a tumour arising in the skin apart from a scar, and to call those arising in a scar "false keloid." But with regard to the first, acne spots, sunburn, "prickly heat," have given rise to keloid. Keloid is considered inflammatory for one reason, because it may spontaneously disappear, but it can be doubted whether this is a sufficient distinction from tumour. Its frequent occurrence has been noted among West African negroes, and Mr. Hutchinson has recorded its

appearance in several members of the same family. It may occur in any scar, whether on the skin or on a mucous membrane, but is perhaps commonest after lupus and tuberculous abscesses. The cicatrix becomes raised, firm, elastic, smooth, pale red, following more or less the shape of the scar. It may be multiple, *e.g.*, in the scars of syphilis or smallpox.

Treatment.—It is generally best not to do anything but to wait for spontaneous disappearance. Only when a steady enlargement points towards fibro-sarcoma should excision be done, and then freely, and an attempt made to obtain a linear cicatrix. Generally excision is a failure, as it recurs in the scar. A belladonna ointment relieves pain and irritation. Recently the *x* rays have been used successfully; certainly this appears better than the painting with iodine or the scarification which has been advised. Mr. Ellis, of Gloucester, claims that keloid can be cured by cutting out the cicatrix, and then as the wound heals raising the edge of the skin daily with forceps, so that no adhesion to the deeper tissues can occur.

Burns and Scalds.

Burns and scalds vary in their effect according to their depth, extent, situation, and the age of the patient. An extensive though superficial burn on the trunk, head or face, especially in a child, may be more serious than a deeper but limited burn on the extremities. A burn is usually said to be more severe than a scald, as the fluid producing the latter generally quickly cools and runs off. A scald, however, owes its severity to the large extent of surface usually implicated, and when produced by molten metal or boiling oil which adheres to the part, is generally very serious. Burns and scalds, when severe, give rise to constitutional as well as local effects. The local effects may be considered under Dupuytren's division of burns into six degrees. These degrees, however, may be variously combined in the same burn.

1st degree.—*Simple erythema*, due to increased flow of blood through the dilated vessels. No tissue destruction ensues, and no scar is left.

2nd degree.—*Vesication*, due to the exudation from the dilated capillaries of the cutis causing the superficial layers of the epithelium to be raised from the deeper in the form of blebs. No scar is left, as only the superficial layers of the epithelium are destroyed, and these are soon reproduced from the deeper layers. Some slight disturbance of pigmentation (an increase or decrease), however, may subsequently remain.

3rd degree.—*Destruction of the cuticle and part of the true skin.*—The epithelium around the hair-follicles, in the sweat-glands, and between the papillæ, escapes, and rapidly forms new epithelium over the granulating surface left on the separation of the sloughs. A

scar results, but as it contains all the elements of the true skin, the integrity of the part is retained, and hence there is no contraction. It is the most painful form of burn, as the nerve-endings are involved but not destroyed.

4th degree.—*Destruction of the whole skin.*—The sloughs are yellowish-brown and parchment-like; and their separation is attended by much suppuration. As the nerve-endings are completely destroyed, the pain is much less than in the former degree of burn. The epithelium which covers in the granulating surface is only derived from the margins of the burn, and the resulting scar consists of dense fibrous tissue. Hence the extensive contraction and great deformity which result unless skin-grafted or treated by Ellis's skin-slipping method.

5th degree.—*Penetration of the deep fascia and implication of the muscles.*—Great scarring and deformity necessarily follow.

6th degree.—*Charring of the whole limb.*—The dead part is separated by ulceration in the same way as in gangrene.

Constitutional effects.—When the burn is superficial and of small extent, there may be no constitutional symptoms; and even when it is deep, but limited to one of the extremities, as the foot or hand, they may also be slight. When, however, the burn is extensive, and especially when it involves the chest, abdomen, or head and neck, even although it is of the first or second degree, the symptoms may be severe, more particularly when the patient is a child. The constitutional effects may be divided into three stages:—1. *Shock and congestion.* 2. *Reaction and inflammation.* 3. *Suppuration and exhaustion.*

1st stage.—*Shock and congestion.*—The shock is often very great, especially when the burn is extensive, and involves the trunk, or head and neck. The patient is pale and shivering, the pulse feeble and fluttering, and the extremities are cold; he suffers little or no pain, and sometimes passes into a state of coma and dies, the chief *post-mortem* appearances being congestion of the internal organs, particularly the brain.

2nd stage.—*Reaction and inflammation.*—Reaction comes on from twenty-four to forty-eight hours after the burn. The pulse is full, strong, and rapid, the temperature rises, and there are other symptoms of fever. Inflammation is set up around the burnt part, and there is now danger of the absorption of the septic products, derived from the putrefaction of the sloughs which are beginning to separate. The congestion of the internal viscera, so common in the former stage, may run into inflammation; and pleurisy, pneumonia, peritonitis, or meningitis may supervene and prove fatal. Perforating ulcer of the duodenum, which is generally situated near the head of the pancreas, may now occur, and is said to be most frequently met with about the tenth day. It would appear to be more rare, however, than has been generally supposed, since no case

has occurred at St. Bartholomew's during the last thirteen years. It was formerly attributed to Brunner's glands taking upon themselves the function of the injured glands in the burnt skin, but is more likely due to the irritation of the toxic products of septic inflammation secreted in the bile and discharged into the duodenum at the bile papilla.

3rd stage.—*Suppuration and exhaustion.*—During this stage, which sets in on the separation of the sloughs, there is still a danger of the patient succumbing to inflammation of the viscera, especially the thoracic; or he may be worn out by hectic and exhaustion from long-continued suppuration. He is also exposed to the risks of secondary hæmorrhage on the separation of the sloughs, and to blood-poisoning from the absorption of septic products unless the greatest care is exercised to prevent the decomposition of the discharges. On cicatrisation occurring, horrible deformity may ensue from the contraction of the newly-formed fibrous tissue in the scars, and later on an epithelioma may arise.

Prevention of burns and scalds.—Apart from their occurrence in connection with fires or other accidents, the vast number result from individual carelessness and neglect of children. Children are allowed to drink out of the spout of kettles and teapots, and then they try to do so when they contain hot fluids, or to play with matches. Lamps burning inflammable oil with glass receptacles are carried about, or even filled without putting out the wick; the result is an explosion in the gas given off by the oil. Old people and epileptics are allowed to sit over fires, where they fall asleep or have a fit. To make matters worse, the windows or doors are opened, the burning people rush distractedly into the open air, whilst friends beat and fan and pluck at their burning clothes. A girl rushing about in only a thin cotton nightdress had large portions of skin torn off in this way. To roll on the floor until some cloth can be thrown over is the one thing that a burning person, a woman in particular, can do, or should be made to do. A friend's life has often been sacrificed. As to prevention in the course of medical work, hot-water tins and bottles when not well covered by blankets cause very troublesome scalds in weakly patients and children. Ether, benzine, methylated spirit, collodion, and loose cotton-wool must all be kept away from a naked light, *e.g.*, cotton-wool used to imitate snow has ignited and caused many deaths.

The **treatment of burns and scalds** must in the first place be *constitutional* and then *local*, not the reverse, for the patient's life is in danger, whilst there is no immediate call for dressing, as the charred surface is temporarily a protection against septic infection, and the germs on the skin have been destroyed. The patient must be put between hot blankets, wet clothes and all, a brandy and nutrient enema given, ether or ammonia injected hypodermically, or saline infusion if the pulse is very weak, and an injection of morphine. As soon as the patient can swallow without vomiting, liquid food and

stimulants are given by the mouth. This is continued until there is a good reaction. A slight case may simply require hot liquid food and a little opiate to produce warmth. But an apparently small scald, the hot contents of a teacup trickling down the neck of a young child, is quite enough to cause its death by shock. After recovery from shock a suitable stimulating line of treatment is required to prevent relapse.

The *local treatment.*—(1) For scorches and blisters of the first and second degrees, air, water, and all antiseptics are most irritating and painful. Carron oil (equal parts of linseed oil and lime water with a little turpentine), calamine lotion, and bicarbonate of soda, especially the first, are the proper fluids for wiping the surface. This should be dressed with lint well saturated with carron oil and covered with plain cotton-wool, or an ointment of boric acid and zinc with vaseline. Vesicles are pricked to let out serum, but the cuticle is not removed. Some paint on nitrate of silver, in a 5 to 10 per cent. solution, others saturate plain gauze with picric acid (picric acid 5, absolute alcohol 80, water to 1,000). But most patients are rendered more comfortable by oil or ointment, which must be changed before being saturated and hardened by serum.

(2) Burns and scalds destroying the skin of the third and fourth degree are not treated with any strong antiseptic, which is very easily absorbed to a poisonous amount, but only with permanganate of potash or boric-acid lotion. The surface is in the first place covered with boric acid or iodoform powder and antiseptic gauze, changed daily. At the second or third dressing, the dead skin, now well defined, is cut through and raised in places to allow of iodoform gauze being slipped beneath. At subsequent dressings the dead skin is cut away nearly up to the line of demarcation which is forming (see *Gangrene*), and thus all sloughs are as quickly as possible removed and a granulating surface obtained, whilst the patient suffers from a minimal amount of septic absorption. As soon as there are healthy granulations, these are covered in with grafts between any islands of skin which may have lived. By these measures are avoided much suppuration and exhaustion and other complications, and the skin-grafting avoids the contracted scars and deformities.

(3) Burns of the fifth and sixth degree are rarely survived unless it be the extremity of a limb which is involved, when amputation would be generally indicated as soon as the primary shock has been removed, not before.

Scars and bands, the result of burns, cause deformities, fix joints, constrict limbs, etc., and so set up venous and lymphatic obstruction. Stretching and multiple divisions leave much to be desired. A better plan is to combine excision with skin-grafting, or to follow Mr. Golding Bird in making a V-shaped incision in the healthy skin at one end of the scar or band, and then dissecting the scar back. The triangular gap when the limb is extended is filled up by grafting.

Lightning-stroke and electric shock.—Death by lightning may be instantaneous; it is so in about 70 per cent.; or the stroke, beyond causing temporary unconsciousness, may do no harm. In some instances, superficial burns, with a fern-leaf pattern on the skin, or paralysis of certain nerves, both cranial and spinal, also hæmorrhages, etc., have been produced. Of late, effects similar to those produced by lightning-stroke have occurred from contact either with wires through which electric currents of high intensity were passing, or with electro-motor apparatus. Death may be due to actual tissue destruction, or to arrest of respiration and asphyxia. In the first case the subject is beyond recovery; in the latter case death may be only apparent, and artificial respiration continued for some hours may lead to recovery. The *treatment* consists in applying warmth, artificial respiration, and stimulants whilst the patient is in a state of shock or suspended animation, with rhythmical tractions and relaxations of the tongue (the *Laborde method* of treating asphyxia).

Sunstroke is produced by dilatation of the blood-vessels of the upper part of the spinal cord and adjacent portion of the brain. It is the effect of the sun's rays before midday falling on the exposed back of the head and neck. It is favoured by muscular exercise in young men without food or water, especially when not acclimatised or when suffering from malaria. As it is not produced by glaring heat, *e.g.*, not in furnace men, it has been thought that the actinic rays produce the effect, and so Dr. Andrew Duncan has suggested an orange-yellow lining for the cap and back of the coat to absorb these rays.

Treatment.—The application of ice to the head and spine, liquid food and rest. For the dangerous coma, ether injections, coffee, flagellations, and, if necessary, artificial respiration. + Bleeding

Asphyxia or suffocation.—This may result from immersion in water, exposure to irrespirable gases, to carbonic oxide and carbonic acid met with in mines, wells, breweries, fires, etc., or from foreign bodies entering the air passages.

Treatment.—Recovery from drowning is generally successful when the time of submersion is under four minutes. Occasionally the person has been brought round after a much longer period, which must always be presumed to be possible, even although he has been under water for a quarter of an hour. First the mouth is cleared by placing the man head lowest, forcing open his mouth and hooking out mud and weeds. Then with his face lowest, the chest and abdomen are forcibly compressed to drive water out of the air passages. Artificial respiration is commenced by seizing the elbows of the patient, pushing them forcibly into his chest, then sliding the elbows forward whilst keeping up the pressure till they meet, then raising the elbows behind the man's head. Or the man is turned on to his face and pressed upon to produce full expiration, then turned on

to his back, by which the chest expands. As soon as he breathes he is to be well covered up with sacks, hay, etc., to stop the rapid loss of heat through the wet clothes. As soon as possible the patient is put to bed; he may first be plunged into a hot bath, then stimulating enemata, hot coffee by the mouth, friction and mustard plasters to the chest and calves follow.

In the carbonic oxide and acid asphyxia the administration of oxygen is a most important addition to the artificial respiration.

Hæmorrhage.

In speaking of the treatment of wounds, it was stated that our first care should be to staunch hæmorrhage. This requires different measures according as it is arterial, venous, or capillary. It is therefore first necessary to be able to distinguish between these varieties. Usually it is quite easy. In *arterial hæmorrhage* the blood escapes in jets, the force of which is increased at each systole of the heart, and is of a bright scarlet colour. In *venous hæmorrhage* the blood wells up from the wounded vessel usually in a continuous stream, and is of a dark purplish-red colour. This is much increased by obstruction of veins above, by dependent positions, by muscular exertion and straining. Hence it is much greater after accidents than at operations. In *capillary hæmorrhage* the blood appears to ooze from all parts of the wound, trickling down its sides to the deeper parts, where it forms a little pool. In some instances, however, as where arterial blood escapes from a deep and devious wound, it may resemble venous blood in that it flows continuously instead of in jets, and when the patient is partially asphyxiated, as from too large a dose of an anæsthetic, it becomes of a dark colour. On the other hand, venous blood exposed to the air in its passage from a deep wound may undergo oxygenation and become bright like arterial, and blood may flow from a large vein, *e.g.*, the hæmorrhoidal, in distinct spurts synchronous with respiration. Bleeding from the corpus spongiosum and corpora cavernosa of the penis, or from like tissues consisting of cavernous blood-spaces or numerous small arteries and veins, is sometimes spoken of as *parenchymatous hæmorrhage*. When hæmorrhage occurs in a visceral cavity, as the pleura, peritoneum, uterus or bladder (*internal hæmorrhage*), or into the substance of the tissues of the trunk or extremities (*extravasation*), it is known by special signs, and is treated of elsewhere.

Constitutional effects of hæmorrhage.—The effect upon the constitution of course varies according to the amount of blood lost, and is more marked when the blood is rapidly poured out from a large artery than when it escapes slowly from a small artery or from a vein. In the former case the patient may die in a few minutes of syncope. When the bleeding is less severe the face and general surface become blanched and cold, and the lips and

mucous membrane pallid. The pulse is feeble, fluttering and rapid, and at length only to be felt in the larger vessels. The skin is bathed in profuse perspiration, the respiration is sighing, the sight dimmed, and the mind wanders. These symptoms may end in syncope, twitching of the limbs or convulsions, and death; or the patient may slowly recover, or may suffer from anæmia or functional disturbance for years. If he is old, some secondary disease is apt to be engrafted on this state of anæmia, of which he may die. Children bear the loss of blood badly, but recover rapidly; the old stand the loss better, but the effect on their constitution is more permanent. In slighter but continued hæmorrhages, such as may occur in piles, uterine fibroids, etc., the patient becomes anæmic, is short of breath, soon tired and exhausted, readily faints on exertion, and may have œdema of the ankles and legs. The pulse in such cases has the well-known hæmorrhagic character, *i.e.*, it is increased in rapidity, and, though full, is readily compressible, completely collapsing during each diastole of the heart.

Constitutional treatment of hæmorrhage.—When the bleeding has been severe, immediate steps must be taken to prevent fatal syncope; and after this danger has been tided over, we must then seek to counteract the remote effects produced upon the whole system by the loss of blood. The surgeon's efforts, therefore, should first be directed to arrest, or at any rate to temporarily control, the hæmorrhage by some of the local measures to be presently described. Having done this, the chief indication is to prevent fatal syncope by ensuring a sufficient supply of blood to the brain to excite the vaso-motor centre in the medulla oblongata. Thus, the patient should be laid on his back with his head low, his body warmly covered up, and hot bottles placed at his feet and about his trunk; and if the pulse does not improve, stimulants in small quantities should be administered, by the mouth if he can swallow, otherwise by the rectum or by subcutaneous injection; whilst in severe cases the legs and arms should be held up, or an Esmarch's bandage applied to them, or the abdominal aorta compressed, in order the better to drive the blood to the brain. After the arrest of the hæmorrhage, infusion of saline solution should be practised. Where the bleeding is internal or cannot be arrested, stimulants should be avoided, inasmuch as the syncope into which the patient has fallen tends temporarily to stop the bleeding by inducing clotting of the blood in the wounded vessels. If the heart be again roused to action by stimulants and the vessels in consequence become dilated, the clots may be displaced, the bleeding re-started, and the last flickering spark of life put out.

Infusion of saline fluid.—Transfusion of blood from the artery of a man into a vein of the patient proves a dangerous procedure from the formation of fibrin in the transfused blood giving rise to emboli and also to toxic poisoning from decomposition of the white

corpuscles, etc. It has been shown, experimentally and practically, that saline fluid has all the advantages and none of the disadvantages of transfusion.

The saline fluid consists of sodium chloride 3j. in Oj. of sterile water at 110° F. As such it may be administered (1) by the rectum with a ball syringe, the patient's head being lowered and the pelvis raised, when one to two pints are slowly injected, and this can be repeated in a quarter to half an hour. The great advantage is the expedition with which, on emergency, this may be carried out.

(2) Subcutaneous infusion is of great value during a severe operation likely to be attended by shock, as it can be kept up by an assistant during the course of the operation, and may be repeated during recovery from the operation. A funnel and rubber-tube is joined to the needle of an exploring syringe, and when this is full of salt solution, the needle is inserted into the loose connective tissue to the outer side of the breast, and the funnel raised three feet or so above the patient. Fluid slowly passes in until a swelling is raised to the size of a child's head, when the needle is changed to the opposite side, and afterwards to the flank. On withdrawing the needle a collodion dressing is applied, and in a few hours the swellings will have gone.

(3) Venous infusion.—A vein, *e.g.*, the median basilic, is exposed and two ligatures put round it, that below is tied tightly, that above is fixed by a single bow to compress the vein. Then a glass cannula or clean catheter is inserted, and the upper ligature used to fix it. The cannula has been previously attached to a funnel and tube and filled with saline fluid. Then two to five pints are slowly run in whilst the pulse is watched. At the end, the cannula is removed, the vein tied, and the wound sutured.

Prolonged anæmia may follow a great loss of blood and require a course of general treatment by rest, diet, and country or sea air, with iron.

The local treatment of hæmorrhage may be considered under the heads of arterial, venous, and capillary hæmorrhage.

Arterial hæmorrhage is spoken of as (1) primary, (2) reactionary or recurrent, and (3) secondary.

(1) *Primary hæmorrhage* is that which occurs at the time an artery is wounded, whether by accident or surgical operation. (2) *Reactionary or recurrent hæmorrhage* is that which occurs on the patient recovering from the shock of the wound or operation after the primary hæmorrhage has stopped, and may be regarded as a failure in the process for the temporary closure of the vessel. The term recurrent, therefore, should only be applied to hæmorrhage occurring within twenty-four hours of the injury. (3) *Secondary hæmorrhage* is that which occurs any time after the first twenty-four hours, and is due to the failure of the process for the permanent closure of the vessel. The treatment in each case is different.

1. Primary arterial hæmorrhage.—It will be best first to consider the natural arrest of hæmorrhage before describing the surgical measures which have been founded upon it. When an artery of small or moderate size is completely divided, the cut end, in consequence of the injury stimulating the muscular fibres of the middle coat, *contracts*, thus lessening the size of the orifice, and, in the case of the small arteries, completely closing it. At the same time, the cut end, owing to the normal elastic tension of the artery, *retracts* within its sheath, leaving the surface of the latter rough and uneven. The diminution in the size of the orifice retards the escape of blood. The slowed current passing over the divided wall of the artery and the roughened internal surface of the sheath, in consequence of this multiplication of points of contact and exposure to the air, coagulates, gradually blocks up the orifice, and fills the sheath around and beyond the retracted end of the artery, forming what is called the *external clot*. The stream having been thus slowed or stopped, the blood inside the vessel also coagulates, and the coagulation spreading from the clot that blocks up the orifice to the first collateral branch, forms what is called the *internal clot* (Fig. 77). The internal clot is of a conical tapering shape of a dark red colour, and only adherent to the vessel walls at its base. When the hæmorrhage has been severe, two other factors favour the formation of these clots, viz. (*a*), the enfeeblement of the heart's action induced by the tendency to syncope, and the consequent diminished force with which the blood is propelled from the divided vessel; and (*b*) the increased tendency of the blood to coagulate owing to an alteration in its composition caused by the absorption of watery fluid from the tissues to make up for the amount of blood lost by the hæmorrhage. Thus the hæmorrhage is arrested, and still presuming that the vessel be of a small or a medium size, it may not recur, and the wounded vessel will become permanently closed in the way to be presently described. It is only, however, when the vessel is small that repair can thus take place. When a large vessel is wounded, the natural process is quite insufficient to prevent an immediately fatal issue; whilst if the vessel is of medium size, as the syncope passes off, and the heart again begins to act with vigour, the clots may be washed away and the bleeding recur till fainting once more ensues. In this way bleedings, alternating with temporary arrests, exhaust the patient's strength, till he finally succumbs to fatal syncope.

Fig. 77.—Diagram of a wounded artery closed by clots.

The method by which the vessel is permanently closed is as follows:—The clot between the artery and the sheath prevents the artery from dilating on the cessation of the contraction of the muscular fibres of the middle coat; whilst the internal clot acts, so

to speak, as a buffer, and thus prevents the force of the blood-stream being exerted to its full on the end of the vessel while healing is taking place. The injury inflicted on the coats of the vessel by its division sets up a preliminary inflammation to a variable extent. Leucocytes and some fluid exudation escape from the vasa vasorum and from the capillaries around, and become mixed with the primary clot. But healing proper commences with the proliferation of the endothelial cells lining the cut vessels and of the connective-tissue cells in its walls (see Figs. 2 and 3). The cells thus formed invade both the external and internal clot. These fibroblasts gradually remove the red cells, fibrin, and inflammatory leucocytes. The clot in and around the vessel becomes paler and intimately adherent. It is next vascularised by young capillaries sprouting inwards from the vasa vasorum, and from the connective tissue around, until the vascularised plug is gradually converted into fibrous tissue. The internal and external plug, as well as the wall of the artery, as far upwards as the first collateral, gradually becomes converted into a fibrous cord from which the newly-formed vessels have disappeared as the scar tissue contracts (Fig. 78).

FIG. 78.—Healing of an artery ligatured in continuity. The ligature comes to be embedded in a spindle-shaped mass, 1, of fibrous tissue derived by proliferation, especially from the sheath and outer coat of the artery. The proximal end is blocked by a clot, 2, which tapers up to the first collateral, 4. The primary clot is invaded and replaced by fibroblasts derived from the inner and middle coat of the artery. On the distal side of the ligature is a smaller clot, 3, tapering to the next branch, 5, by which anastomosing vessels bring blood into the artery as shown by the arrows. Between 4 and 5 the vessel becomes converted into an impermeable cord.

The internal clot in the distal end is often less perfectly produced, and may not be formed at all. Consequently, secondary hæmorrhage is more frequent from the lower than from the upper end of a ligatured artery.

When an artery is merely punctured, the arrest of hæmorrhage will depend upon the size of the vessel, and the size and direction of the puncture. A wound, however small, of the aorta, or of a vessel next removed in size, will probably be fatal. In a vessel of less magnitude, when the puncture is small, a clot forms of an hour-glass shape, thus blocking up the wound, and healing from the margins occurs by cell-proliferation. A somewhat larger wound, when made longitudinally to the artery, may heal in the same way; but when made transversely to the axis of the vessel, it assumes a diamond shape, in consequence of the elastic retraction of the coats, and the hæmorrhage will probably not be arrested spontaneously.

The surgical methods of arresting hæmorrhage may be considered under the heads of temporary and permanent methods.

1. *Temporary methods of arresting hæmorrhage.*

The surgeon, if the bleeding point is within reach, need never fear hæmorrhage, as mere pressure with the finger will control it, whatever the size of the vessel, till he can obtain the means of permanently arresting it. The pressure should be made directly on the bleeding point, aided, if need be, by pressure between the wound and the heart; in the former situation with the finger, pressure-forceps, or plug of gauze, combined with elevation; in the latter situation with the finger or the tourniquet, the pressure being then made in such a direction as to press the artery against some resisting structure, as a portion of bone.

Fig. 79.—Petit's tourniquet.

Fig. 80.—Signoroni's tourniquet.

The tourniquets employed are various (Fig. 79 and Fig. 80). The rubber tube of the Esmarch's apparatus perhaps answers the best. An impromptu tourniquet may be made by tying a pocket-handkerchief loosely round the limb, and twisting it up tightly with a walking-stick or umbrella. These temporary means, however, are only supplementary to direct pressure.

Tourniquets are rarely of service, and then only in skilled hands. If a tourniquet be applied above a wound, without keeping up direct pressure, unless screwed so tightly as to arrest all the arterial flow, no easy matter as a question of first aid in a conscious patient, the result is venous obstruction. Blood continues to flow into the limb by the main artery, but none escapes by the more compressible veins. The result is a raising of venous blood tension and an increase of venous hæmorrhage from the wound. A patient will be soon rendered exsanguine even from such a small lesion as a ruptured

varicose vein, and more quickly still in the case of a compound fracture, if a partially tight band be placed round the thigh and the wound be not compressed.

Direct pressure with elevation is the method for temporarily arresting hæmorrhage; it admits of prompt application. A tourniquet takes time to apply, whilst blood is being lost, and if blood is not flowing fast, the tourniquet is unnecessary. If direct pressure is insufficient digital pressure should be made on the artery above, by which the venous return is not greatly or at all impeded.

2. *Permanent methods of arresting hæmorrhage.*

(1) *Ligature* is the most reliable method of permanently arresting hæmorrhage, and is the one most frequently employed.

Fig. 81.—Artery forceps.

Silk, carbolised and chromicised catgut, kangaroo-tail tendon, are the materials chiefly used as ligatures (see p. 185). For the ligature of arteries in their continuity, the choice of ligature is still open to question, and will be referred to again under *Ligature of Arteries* (*q.v.*). Whatever form of ligature is used it should not be too thick, or the internal and middle coats will be unevenly divided or may escape division altogether. At the same time it should be strong enough to resist absorption or softening till the artery is securely sealed. An artery is tied in an open wound by seizing the cut end with nibbed forceps (of which Fig. 81 is one of the best forms), drawing it gently from its sheath, throwing a ligature round it, and then tying the ligature in a reef-knot or a surgeon's knot (Fig. 82, A and C). Both ends of the ligature are then cut off short.

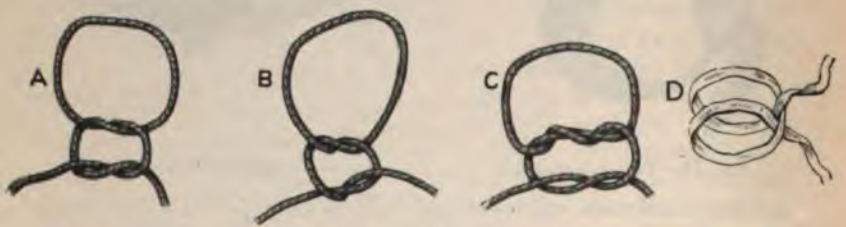


Fig. 82.—A. The reef-knot; B. The granny-knot; C. The surgeon's knot; D. The clove-hitch.

If this cannot well be done, especially when the end of the artery is torn or sloughing, a dissection is carried up the line of the vessel

until a sound point is reached, and then a ligature is put round by aid of an aneurysm needle (Fig. 83), as described under *Ligature of Arteries.*

For the *ligature of the cut end of an artery*, either a reef-knot or a surgeon's knot, drawn as tightly as possible, is always used. The objection to the reef-knot is that the first hitch may yield before the second hitch can be tightened. Also after tightening the second

Fig. 83.—Aneurysm needle.

hitch, one end must not be drawn upon, or the reef-knot may turn into a slip-knot and yield. The first hitch of the surgeon's knot is made of two turns, and being drawn as tightly as possible should not yield until the second hitch, which is made with only a single turn, is also tightened.

For the *ligature of an artery* in continuity either a reef-knot or a surgeon's knot is generally used, and it has been thought best hitherto to draw the first hitch so tightly as to cut through the inner and middle coats, which can be felt to yield. On inspecting the result of such a ligature by slitting up the artery, a clean-cut division of the inner and middle coats is seen (Fig. 84), the elastic fibres causing the divided ends to curl inwards towards the lumen of the artery, whilst the outer coat of fibrous tissue is simply compressed in the grasp of the ligature. The division of the inner coat, followed by its curl inwards, has been hitherto deemed of much importance in forming a firm internal clot.

Fig. 84.—Diagram of a ligatured artery. E. External; M. Middle; and I. Internal coat. L. Ligature.

Messrs. Ballance and Edmunds, however, have contended that this division of the inner coats unnecessarily weakens a large artery, and by so much favours the occurrence of secondary hæmorrhage. They propose a "stay-knot," formed by putting two ligatures side by side. They first put round the artery two ligatures and make on each separately the first hitch of a reef-knot, which they tighten just sufficiently to compress and close the lumen of the artery without dividing the coats, and then taking the ends of the ligatures on either side, the second hitch of a reef-knot is made by tying them together. Some have objected to this measure as often impossible, since that, when the ligature is tightened, the

artery is so folded that the projections of the folds inwards are cut through at their apices before the lumen is closed. Practically, good results have been claimed from this method; on the other hand, a return of the circulation has in other cases taken place requiring another operation and the re-application of a tighter ligature.

Ligature of pedicles.—Whenever tissue is included in the ligature

Fig. 85.—Stay-knot (Ballance and Edmunds). If there is much tension, two loops may be thrown in the first hitch, as in a surgeon's knot.

in addition to the vessel, especially when this consists of œdematous unstriped muscular and fibrous tissue, the tissue is likely to slowly

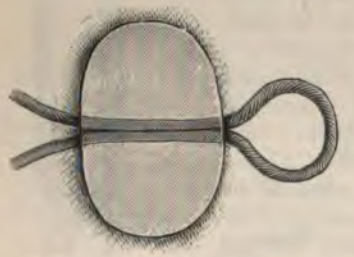


Fig. 86.—Pedicle transfixed by a doubled ligature.

Fig. 87.—Interlocking pedicle ligature. The doubled ligature is divided at the loop, the two halves interlocked and brought round either side, where each is tied by a surgeon's knot.

yield under the pressure of the ligature, which, if it is simply encircling the tissue, slips off and hæmorrhage recurs. Hence in all pedicles of tumours, in ligaturing the spermatic cord in course of castration, and in all other places where tissue outside the vessel has to be included, the ligature is applied by transfixion, as shown in the diagrams, 86 to 90, and then slipping cannot take place.

(2) *Pressure and forcipressure.*—Pressure by the finger or sponge continued for several minutes is sufficient to allow of a clot forming in capillaries, arterioles and veins.

Bleeding from an oozing surface, such as cavernous tissue and surfaces bared in tearing through adhesions, shelling out tumours, etc., is stopped by suturing the surfaces together firmly.

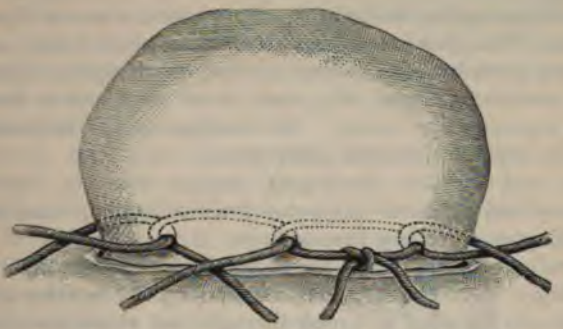


Fig. 88.—Four ligatures interlocking for a thick pedicle.

Fig. 89.—Pedicle ligature (Bantock's). One end is passed round the pedicle and through the loop; the ends are then drawn tight and tied on one side.

Fig. 90.—Pedicle ligature (Staffordshire knot). After transfixing the pedicle the loop is widened and brought back over the tumour; one free end is then carried over the loop round the pedicle on one side, and the other free end under the loop and round the opposite side, the knot being opposite to the point at which the pedicle was first entered by the needle.

Strips of iodoform or other gauze are used as a plug or tampon, especially for cavities with walls, *e.g.*, the nose, vagina, tooth-socket, bone- or abscess-cavity, etc. The end of the strip is placed firmly against the chief bleeding point, and the strip then packed against it in regular folds up to the surface, where a short end is left free. The plug is removed after twenty-four hours, or several inches are pulled out each day so that no discharge shall collect behind, until at the end of a week or so the whole is drawn out, leaving a granulating cavity. By twisting up the free end of the gauze, the strip is the more easily drawn out.

Firm and equable bandaging greatly controls oozing after operations and prevents blood-clot from collecting, breaking down and setting up secondary hæmorrhage.

A graduated compress, made by cutting squares of lint each a little larger than the previous one, piling the squares to form a pyramid and running a thread through the whole, was frequently employed for the pressure of an artery against a firm surface, as in the case of the scalp against the skull or in wounds of the palmar arch, and this was supplemented by tightly knotting a bandage over the compress. But this pressure causes pain and leads to suppuration and sloughing. Nowadays, the bleeding vessel is sought for and tied.

Forcipressure consists in seizing the bleeding artery, and the surrounding tissues if the vessel is small, with Spencer Wells' or other pressure-forceps, leaving them on a few minutes and then very gently withdrawing them. It is a means often used to control the hæmorrhage during an operation, and will even permanently arrest it in the case of the smaller vessels, which are often found not to bleed when the forceps are removed. It is sometimes employed for arresting hæmorrhage from a vessel which from its depth or other cause cannot be tied. In such a case the forceps are left on from twelve to twenty-four hours, and at the end of that time are very gently removed so as not to re-start the bleeding.

Powerful pressure-forceps closed by a screw or strong ratchet crush a vessel or vascular tissue out into a thin membrane, *e.g.*, Pollock's pile crusher, Doyen's forceps. This may have to be done somewhat slowly, or friable tissue is cut through as if by a knife. The crushed tissue may be left, trusting to the mechanical closure aided by clotting above, or it may be ligatured or cauterised.

(3) *Torsion* is in common use for small vessels. These are seized by clamp forceps, which are then twisted round half a dozen times or so until they come away. It is especially useful and avoids a ligature when the vessels are running in loose connective tissue. It fails in friable tissue, which breaks away before the vessel is twisted enough, and in tough tissue in which the vessel untwists. In such tissues a ligature should be employed without waste of time

through the necessity of having to pick up the bleeding point again. Torsion has been applied to large vessels, especially at Guy's Hospital, but with better material for ligatures is likely to be little used. A large artery, *e.g.*, the femoral, is seized at its end (Fig. 91) with clamp forceps and drawn out of its sheath for an inch or so, where it is held by a second pair of forceps, whilst the one on the end twists the intervening portion of the artery about six turns until the internal and middle coats have given way, and the artery no longer untwists when let go.

The other methods of arresting hæmorrhage are of less importance.

(4) *Cold* is only applicable to stopping hæmorrhage from small vessels. It acts by causing the muscular coat to contract, thus promoting the coagulation of the blood in the arterioles and capillaries. It is frequently employed in the form of cold water or ice to arrest bleeding from the smaller vessels in bruises, sprains, hæmorrhage into joints, or on mucous membranes, *e.g.*, for epistaxis. It is not now employed for large wounds, as the cold increases shock.

Fig. 91.—Effect of torsion on an artery.

(5) *Heat* in the form of hot water is now often used in large operation wounds. The water must be hot (120° to 160°); warm water merely encourages the hæmorrhage by washing away the coagula blocking the vessels. Hot water acts by stimulating the muscular fibres of the vessel to contract. It also causes coagulation of the albumen of the blood. Superheated steam, atmocausis, directed on the bleeding part through a metal tube has been employed of late in curetting the uterus, etc., and in arresting hæmorrhage from erectile structures as the urethral bulb and from parenchymatous organs as the spleen or liver.

(6) *Styptics* are substances supposed to check hæmorrhage by inducing the coagulation of the blood, as perchloride of iron; by favouring fibrin formation, as matico leaves or Wright's fibrin ferment; or by causing marked contraction of small vessels, as suprarenal extract, hamamelin or ergotin. They are but little used, for either they are inefficient or may do harm. Suprarenal extract has been introduced of late to check bleeding from mucous membranes, *e.g.*, of the nose, where it causes the mucous membrane to become markedly pale and anæmic, and facilitates operations; but a paralytic reaction follows, and then hæmorrhage may recur profusely. Perchloride of iron is rarely necessary for plugging a tooth-socket; it is now gross malpraxis to apply it for stopping hæmorrhage from a wound, as extensive sloughing follows. For uncontrollable hæmorrhage from a leaking aneurysm no good results, and

it is better omitted. Bleeding from a tooth-socket is best checked by plugging with iodoform gauze. If perchloride of iron is used, a strip of lint should be soaked in it and dried before insertion, and the plug should be taken out within twenty-four hours.

(7) *The cautery* arrests bleeding in part by causing the muscular coat of the artery to contract, in part by inducing coagulation of the blood, and in part by searing the tissues and so producing an eschar which checks or prevents the flow of blood. The wound should be first dried by pressure with aseptic gauze or lint, and then immediately touched lightly with the cautery, which should be at a dull red heat, so as to sear, producing a brownish film, not charring the tissues black. If used at a white heat the cautery cuts like a knife, and the hæmorrhage continues. It may be applied in the form of the cautery iron, which is simply heated in the fire; but Paquelin's benzoline cautery and the galvano-cautery are much more convenient. The chief objection to the use of the cautery is that it causes destruction of the tissues around, and on the separation of the resulting eschar secondary hæmorrhage is liable to ensue. The cautery should never be used in a clean-cut wound. By some it is systematically used in removing nasal polypi, piles, also in outlining and removing cancers on mucous surfaces. Firm plugging with gauze, antiseptic wax for bone surfaces, etc., now replace the cautery.

(8) *Acupressure* consists in securing the end of the bleeding vessel by pressing it between a needle or a hare-lip pin and the tissues, or between the needle and a wire twisted over the needle. This method is scarcely ever used now except for arresting bleeding from a puncture of the skin, a leech bite, or a varicose vein of the scrotum, etc.

2. Recurrent, reactionary, or intermediary hæmorrhage is that which may come on within the first twenty-four hours after a wound as the patient gets warm in bed, and the shock of the operation or injury has passed off. It may be regarded as a failure in the process of the temporary closure of the vessel. It should be noted that the term recurrent is by some authors applied to what is here called secondary hæmorrhage. *Causes.*—1. Slipping of a ligature or displacement of a clot from a vessel consequent upon the wounded parts not being kept at rest. 2. Washing out of a clot from a vessel which it has temporarily plugged, by the increased force of the circulation as the heart regains power on the passing off of the syncope or shock. It is not uncommon in large wounds to have some oozing of blood through the dressings; but this should not be considered as recurrent hæmorrhage unless it occurs in unusual quantities, and only then calls for treatment. The soiled dressings having been covered with fresh layers of the antiseptic gauze and wool, the part should be firmly but gently bandaged and then elevated. This packing failing, the dressings must be removed,

and the flaps in the case of an amputation separated, the clots washed away with some hot antiseptic solution, and any vessel found bleeding, tied. The wound should be then redressed and firm pressure applied. It is better to anticipate this by careful ligation of bleeding points before completing the operation, and when this cannot well be done the wound should be filled with gauze for a day or two and then sutured secondarily.

3. Secondary hæmorrhage occurs after the period of reaction in consequence of the failure of the process for the permanent arrest of hæmorrhage, generally within a fortnight or three weeks of the operation. It is now rare owing to its chief cause, septic infection of the wound, being largely prevented. But it must be watched for when the main vessels are found diseased by atheroma or syphilis, and if it occurs, generally does so before the third week is over.

Cause.—Secondary hæmorrhage is due either to the defective formation of the internal clot, or to the failure of union of the internal and middle coats. Either of these, again, may be (*a*) the result of some fault in the surgical means taken to arrest the primary hæmorrhage or in the treatment of the wound, and then in some measure may be said to be preventable; (*b*) the result of some disease of the vessel or constitutional state of the patient, and then may usually be regarded as non-preventable. These causes may be considered under the following heads:—

1. *Defect in the ligature or in its application.*—(*a*) An improperly prepared animal ligature may become absorbed too soon. (*b*) A non-absorbable ligature, if chosen, may be too thick or tape-like, and hence not divide or unevenly divide the internal and middle coats. (*c*) The ligature may not be aseptic, and so cause septic arteritis and suppuration, preventing repair of the arterial walls. (*d*) The ligature, whatever kind is used, may be tied too loosely, or be unevenly knotted, or include foreign tissue. (*e*) The sheath, in applying the ligature, may be too freely separated from the artery, or the artery bruised during the separation of the sheath. (*f*) The ligature may be placed too near a collateral branch, so that the internal clot is disturbed.

2. *Defect in the management of the wound.*—The tissues may be roughly handled and bruised, or the wound may be allowed to become infected by pathogenic organisms, or discharges may collect and decompose, so that septic inflammation and suppuration may be set up and spread to the vessel and its contained clot. *Septic changes* in the wound are by far the most frequent cause of secondary hæmorrhage, a fact that should be especially borne in mind when a large artery has to be dealt with.

3. *Disease of the vessel-walls.*—Under this head may be mentioned atheroma, calcareous degeneration, and syphilitic and tuberculous disease, all of which may either allow the ligature to

cut its way too quickly through the diseased coats, or by delaying repair prevent the adhesion of the internal and middle coats and the other changes that should occur in the normal process of healing.

4. *Constitutional conditions.*—These are such as render the blood less coagulable than usual, or are associated with an increase of the blood pressure and an over-action of the heart. Amongst such conditions may be mentioned the hæmorrhagic diathesis and Bright's disease.

Symptoms.—There may be a sudden and even fatal gush of blood, or previous to this, the discharge from the wound may have been blood-stained. In some cases the bleeding may stop for a time, but again and even again recur till the patient finally sinks from exhaustion. Sometimes the hæmorrhage may cease spontaneously after one or more bleedings, and the patient recover. This, however, is quite the exception, and must in no case be relied on by the surgeon. In all cases of secondary hæmorrhage, prompt measures should be taken to secure the bleeding vessel, even although the hæmorrhage may have been slight and for the time may have apparently ceased, since a more severe hæmorrhage is practically sure to follow.

Treatment.—A. *From an artery in a stump after amputation.*—The treatment will differ according to (1) the date at which the hæmorrhage occurs; (2) whether it is from the main artery; (3) the condition of the stump; and (4) the situation of the amputation. Thus, when the hæmorrhage occurs *a few days* after the operation, and is little more than a mere oozing, elevation and pressure by careful bandaging will often stop it. If it should not do so, or the bleeding is more severe and appears to come from the main artery, the flaps appearing distended with blood, the wound should be opened up, the clots removed, and the bleeding vessels secured. At a *later period*, when the healing process has considerably progressed, should pressure fail, it becomes a question whether the healing flaps should be torn apart and the artery secured at its bleeding point, whether the main artery should be tied above the wound, or whether re-amputation should be performed. If the main artery can be easily secured just above the operation wound, this is the proper procedure, especially if the wound is in a sloughy condition, in which case the ligature would probably not hold at the seat of bleeding. This is also the right course to pursue if the amputation has been performed at the shoulder or hip joint, the subclavian or external iliac being ligatured; but if in the lower third of the leg or in the forearm, then an attempt may be made to tie at the wound, or if this is impossible from the sloughy condition of the stump, re-amputation is probably the safest treatment. In any case measures should be taken to render the wound aseptic, as it is

only by so doing that a recurrence of the hæmorrhage can with certainty be prevented. It is best to fill the wound with gauze and bring its edges together later.

B. *From an artery in its continuity.*—Pressure should be applied at the seat of wound whilst the diagnosis is doubtful. The best plan, as a rule, is to cut down upon and tie both ends of the bleeding artery in the wound. Tying the main artery at a distance above the wound has been advised, but is open to the objection that the secondary bleeding may come from the distal end of the artery; and that even when it comes from the proximal end, the ligature of the main vessel may not control it, since blood may be carried into the artery below the ligature by the collateral branches (see Fig. 78, p. 210). Further, in the case of the lower extremity there is also a danger of gangrene. The operation of tying at the seat of wound is no doubt difficult, as the parts are generally matted together in a sloughy condition, and the coats of the artery so softened that a ligature will not hold; but by following the artery a little way upwards and downwards, a healthy portion may be found whereon to place the ligature. The steps of the operation are greatly facilitated by the use of Esmarch's bandage; or when the hæmorrhage comes from such an artery as the external iliac, subclavian, or carotid, the loop of a ligature is placed round the artery above, which is then drawn forwards against the finger. Should hæmorrhage recur after both ends of the artery have been tied at the site of the wound, amputation is probably the safest course, or possibly a ligature above and firm plugging of the wound.

Venous hæmorrhage.—This is severe only when there is some obstruction to the return of venous blood owing to the part being dependent, or the main vein above being compressed by a tumour or by a band. When a vein is cut completely across, the arrest of hæmorrhage is due chiefly to the formation of a coagulum in its interior, but partly to the collapse of the vein. *Treatment.*—Unless a large vein is wounded in its continuity, no treatment beyond pressure is usually required. This may be done by plugging the wound or by a firm bandage. Should the main vein bleed after an amputation, a ligature should be applied to it. A puncture in a vein may be sutured, or better a lateral ligature applied. (See *Treatment of Wounded Veins.*)

Capillary hæmorrhage is arrested by the formation of coagula in the capillaries and smaller arterioles. The coagulation is due in part to the drying of the blood in the air; in part to the inflammation set up in the capillary wall by its division; and in part to the diminished force of the circulation in the capillaries consequent upon the reflex contraction or even closure of the arterioles which follows the division of the tissues. *Treatment.* — As the hæmorrhage usually stops spontaneously, nothing in the way of treatment is

as a rule, called for. Ice-cold or hot water, firm pressure, suture, or bringing the surfaces of the wound together, will then check it.

THE HÆMORRHAGIC DIATHESIS—HÆMOPHILIA.

Hæmophilia is a condition in which bleeding is prone to occur spontaneously or on the slightest provocation, and is very difficult to arrest. The cause is unknown. The condition, however, appears to be hereditary, in that it often occurs in members of the same family, and nearly always in the males, although it is almost invariably transmitted through the female line. The pathology of the disease is obscure, but the arteries have been found thin, the left ventricle hypertrophied, and the different forms of leucocytes in the blood relatively altered in number. The time the blood takes to clot is prolonged from five to fifteen or thirty minutes. The bleeding may be started by the most trifling injury, such as a mere scratch of the finger, the extraction of a tooth, or a bite of the lip or tongue. Or it may occur spontaneously, when it is sometimes preceded by flushings of the face and throbbing of the arteries, and then commonly takes the form of epistaxis, or of extravasations beneath the skin, or of bleeding from the gums or intestines, or of effusion into a joint (see *Joints*). When the result of a traumatism, the blood, except a large artery is wounded, oozes from the injured surface in a steady, continuous, and uncontrollable stream. The bleeding may last for weeks, and then cease spontaneously, leaving the patient in an anæmic condition, from which, however, he may speedily recover; or it may terminate fatally by epistaxis, melæna, or cerebral hæmorrhage. Successive attacks are common at varying intervals, and to one of these the patient generally succumbs. Should, however, he survive the period of puberty, there is a fair chance of the tendency to bleed decreasing with advancing years. The *treatment* consists in placing the patient at perfect rest in the recumbent position, in applying firmly a graduated compress or tampon of gauze, and in elevating the part when the bleeding comes from a limb. Internally chloride of calcium may be given in doses of ʒj. every hour or two by the mouth, or in double doses in enemata until the bleeding is checked, then reducing to three times a day—an additional guide is the reduction of the coagulation time after Prof. Wright's method. Ligature, the actual and galvanic cautery and acupressure only do harm by increasing the size of the wound; and cold, in the form of ice, is of doubtful benefit. When the blood comes from a tooth-socket a plug of perchloride of iron may be applied.

CONSTITUTIONAL EFFECTS OF INJURY.

Shock is the term applied to a sudden diminution in the force of the circulation through an accident or an operation. It may be the result of a severe and direct impression on the central nervous system or on the peripheral nerves, or it may occur from acute hæmorrhage

or from septic infection. These causes may act separately, or all three, nerve irritation, hæmorrhage, and septic infection, may be combined. Among the exciting causes of shock are :—

(1) Nervous causes: (*a*) Fright in connection with an accident, or fear of an operation, of which, indeed, patients have died before being touched by the surgeon ; (*b*) injury to the brain or spinal cord ; (*c*) peripheral excitation, *e.g.*, of the abdominal sympathetic from irritation of a biliary or renal calculus, sudden variations in tension as in tapping for ascites, or even the sudden emptying of an over-distended bladder or intestine, extensive irritation of the skin as in burns and scalds.

(2) Septic poisoning, especially the rupture of an abscess into the peritoneal cavity, snake-bites, and other poisons.

(3) Hæmorrhage, whether external or internal.

(4) Loss of heat from exposure to cold and long immersion in water, starvation, excessive muscular fatigue.

Among the predisposing causes are general affections, such as cardiac and hepatic mischief, Bright's disease, alcoholism, obesity, and sedentary occupations ; also an excitable hysterical temperament, extreme youth and old age.

Pathology.—The above-mentioned causes of shock, exciting and predisposing, by their influence on the central nervous mechanism lead to an impairment of vaso-constrictor tonus, especially a dilatation of the splanchnic arteries. The result is a fall in blood-tension. The fall in blood-tension leads to a deficiency in the blood-supply to the cardiac muscle, and with a weakening of the force of the heart a further lowering of tension takes place and an additional impairment of the nervous vascular mechanism. The fall of blood-tension thus works in a vicious circle. If the tension is not raised the blood will gradually collect in the veins ; in other words, the patient slowly dies from failure of the circulation.

The *symptoms* vary in severity. In extreme cases the patient lies in a semi-conscious state. His pulse is feeble, frequent, and fluttering, perhaps hardly perceptible at the wrist. The surface, especially that of the extremities, is cold, the temperature falling at times to 97°, or even 96° ; the face is pale, the lips are blanched ; the skin is moist or covered with a clammy sweat ; the eye is half closed, and lustreless or glazed ; and the respiration is shallow, and may be barely perceptible. There is marked muscular relaxation ; there may be yielding of the sphincters, and at times nausea and vomiting. The symptoms may gradually increase, and the patient die of syncope or asthenia ; or he may gradually rally and return to the normal, or pass into the condition known as *reaction*. The pulse becomes full and increased in frequency, the temperature raised, the face flushed, the skin hot and dry, the urine scanty and high-coloured, the tongue furred, and the bowels confined. But these feverish symptoms, formerly regarded as the result of reaction,

are now known to be due to septic poisoning. Unless the pulse and temperature soon become normal, the prognosis may be bad.

Treatment.—In slight cases the patient is covered up warmly in bed with blankets, and hot bottles, well wrapped-up, are applied to the feet, and when there is much pain a subcutaneous injection of one-sixth of a grain of morphia or a dose of Dover's powder given. In severe cases, small and repeated doses of brandy should be given, carefully watching its effect upon the pulse so as not to subsequently induce excessive dilatations of cutaneous vessels; whilst hot bottles should not only be applied to the feet, but placed on either side of the thorax, and friction used to the hands and surface generally. If there has been severe hæmorrhage, fluid nourishment in small and oft-repeated doses should be administered with the stimulant. In extreme cases, and especially after operations, where the patient is unable to swallow, brandy should be administered by the rectum, with a nutrient enema or a hot saline solution, also ether or strychnine (gr. $\frac{1}{60}$) injected subcutaneously; whilst, should the breathing cease, artificial respiration ought to be employed and persevered in for some time, although at first it may apparently be ineffectual. The application of heat by means of hot bottles and warm blankets must, in the meantime, on no account be neglected. Hot flannels placed over the cardiac region may be successful in rousing the flagging heart; and in the case of a child a hot bath may be tried. Should the jugular veins be distended, indicating an over-full and partially-paralysed condition of the right side of the heart, the external jugular vein may be opened. On the other hand, if there has been excessive hæmorrhage, infusion of saline solution should be performed, either into the veins or subcutaneously, the extremities in the meantime being elevated and bandaged so as to raise as much as possible the blood-tension in the nerve-centres and feebly active heart. Indeed, where no special bleeding has taken place, saline infusion has a most beneficial influence on shock.

Many patients suffering from shock have been found to react for a short time to strychnine, and the consequence has been its rather indiscriminate use, and the patient's end has been sometimes attended by respiratory or general spasms. The dose should be $\frac{1}{60}$ gr., which may be repeated up to six times, *i.e.*, a total dose of $\frac{1}{10}$ gr., but no more should be given until sufficient time has elapsed for the drug to have been eliminated.

Traumatic fever was a term formerly much used for mild fever following an injury or accident. It is either a toxinæmia or slight septicæmia (see p. 48).

Traumatic delirium is the term applied to the delirious state which sometimes supervenes after injuries and surgical operations. The delirium may depend upon several distinct conditions. Thus (1) it may be merely a symptom of septic fever (*septic delirium*).

(2) It may occur in the highly nervous or neurotic as the result of severe mental strain or exhausting brain-work previous to the injury or operation, being then spoken of as *nervous traumatic delirium.* (3) It may be the result of the long-continued abuse of alcohol, and is then ordinary *delirium tremens* brought on by accident or operation. These various forms, however, no doubt often occur together.

Septic delirium.—Of this variety little need be said further than that it generally occurs from the third to the fifth day, when absorption is at its height, and that it usually begins or is worse in the night and abates with the morning remission of temperature. The *treatment* is directed to the better drainage of the wound, etc., with the addition of an ice-cap to the head when the delirium is high, also morphine injections.

Nervous traumatic delirium, though rare, sometimes occurs in subjects of a susceptible nervous temperament or over-exhausted with brain-work. It is unaccompanied by fever and closely resembles delirium tremens, except that it is not due to alcoholism. The delirium, which is usually of a low and muttering, but occasionally of a violent or maniacal character, generally yields to absolute quiet and hypnotics, opium, bromide of potassium and chloral, etc., with careful feeding and the judicious employment of stimulants where such are indicated. The patient must be carefully watched.

Alcoholic traumatic delirium or delirium tremens differs from the inflammatory variety in the absence of fever, and in the peculiar nature of the delirium, which is of a low muttering or busy kind. The patient has delusions, fancies that he sees animals or devils under his bed or in the air, is suspicious of his friends, talks constantly to himself, answers rationally when spoken to, but immediately relapses into his incoherent muttering state. Sometimes the delirium is of a violent character, the patient will not remain in bed, and may attempt to destroy himself or those around him. The temperature is normal or but slightly raised; the skin is perspiring; the hands are tremulous; the pulse is full, soft, and often quickened; the tongue is also tremulous, indented by the teeth, and coated with a creamy fur, and in severe cases becomes dry and brown. The bowels are usually confined, and there may be transitory albuminuria depending upon disturbance of the renal functions and quite irrespective of chronic Bright's disease. The patient cannot sleep, and will not of his own accord take solid food, but will, as a rule, drink anything.

The *prognosis* is good when the patient is young, and can be induced to take nourishment; but when he is broken down in health or the subject of visceral disease he usually sinks into a state of asthenia, and dies of exhaustion, or it may be of heart failure during a paroxysm of violence.

Treatment.—The chief indications are to make the patient take

nourishment and to procure sleep, and so restore power to the exhausted nerve-centres. Thus, the digestive functions should be regulated by clearing the bowels with a purgative or an enema, and by the subsequent administration of tonics, such as quinine. The difficulty in getting the patient to take food may generally be overcome by a judicious mixture of firmness and coaxing, otherwise he must be fed by a nasal or œsophageal tube. The diet should consist of fluid nourishment given in small and repeated quantities by night as well as by day, provided the patient is awake. To procure sleep subcutaneous injections of morphine (gr. $\frac{1}{6}$), or bromide of potassium and chloral in doses of twenty grains of the former to fifteen of the latter, may be given every two hours, carefully watching their effect. Success has sometimes been obtained by first inducing insensibility by chloroform, and following up its effects by the subcutaneous injection of morphia. This plan is, however, by no means free from danger, since three deaths occurred at St. Bartholomew's alone in seven years. If there is kidney disease, morphia and opium should be given with great caution, but it is a risk which has often to be run. The question of the administration of stimulants is one on which surgeons differ. Perhaps the best rule is—where the patient is young and of good constitution, to withhold them entirely; but where he is old, broken down in health, or the subject of visceral disease, to give them in moderate quantities, regulating the dose according to the amount of depression and the effects produced. If he is violent or noisy he must be isolated, and prevented from injuring himself or his attendants, either by the use of the strait-jacket or by manual restraint. Seclusion itself has often a good effect in producing sleep. The management of a local injury is often rendered very difficult by the patient tearing off bandages, splints, etc., and thus, for example, converting a simple fracture into a compound one. Such mischief can only be prevented by the greatest watchfulness and care.

ANÆSTHESIA.

General anæsthesia.—The administration of a general anæsthetic to a patient not only spares him the pain of an operation, but whilst he is still drowsy from its effects, the pain caused by the operation has time to subside. Thus he does not retain the remembrance of a painful ordeal, is ready to submit to another operation should the necessity arise, or to recommend one to his friends, at an early moment, when a successful issue is the more likely. Further, the surgeon can carry out the operation deliberately and the more easily, undisturbed by the patient's movements or by muscular rigidity. The anæsthesia required need not necessarily be complete from the commencement to the pinning of the bandage, nor can it be measured by the dose, but it should be just that depth required for the

individual patient at the particular stage of the operation. It is not so much the special kind of anæsthetic, but the skill with which it is administered that is necessary to attain the above result. And a sufficient competence in administration of anæsthetics must be reached by every student, viz., by attending the practical instruction given by the special anæsthetist on the staff of the hospital.

Under these circumstances, together with the proper preparation of the patient beforehand, and the suitable dieting after the operation, the objections to a general anæsthetic for most cases are removed. The patient experiences after awaking a period of nausea and sickness, but this is only partly the effect of the anæsthetic; it is partly the consequence of the operation, for it occurs when no general anæsthetic is given; and the restrictions as to diet, etc., are necessary, especially in abdominal cases, for other reasons.

Local anæsthesia is of limited application only; its chief uses are in ophthalmic, rhino-laryngeal, and a few other superficial or limited manipulations. We strongly advise against its general adoption. As to the spinal injection, to be mentioned below, we can see no indications for its employment, only great risks. Local anæsthesia may get rid of the pain, but nothing else. Even if the patient can restrain his emotions, he nevertheless undergoes considerable mental stress, and can rarely be got to submit to a second ordeal. Its general adoption would strengthen disinclination to follow surgical advice, and lead to the postponement of many operations until too late. Neither is it free from danger, from emotional shock; from excessive dosage of the drug, nausea and sickness follow; and in abdominal cases pneumonia has been shown to ensue as often as after a general anæsthetic.

Stages of general anæsthesia.—(1) *Emotional excitement.*—There is in patients who cannot control themselves, emotional excitement; children struggle and scream, adults make sudden conscious impulsive movements with laughing or crying. The breathing is apt to be irregular, shallow; the patient holds his breath until he is cyanosed, and then often takes very deep respirations, so that an excessive amount of the drug may be suddenly inhaled. The pupil often dilates. This is a stage which should be got over as soon as possible by giving the anæsthetic concentrated. Too much air with the nitrous-oxide gas or ether aggravates matters. During this stage the patient's breathing should be as nearly regular as possible both as regards rate and depth.

(2) *Analgesia.*—This is a placid state of imperfect consciousness with superficial respiration, as when dozing, and corresponds to partial drunkenness from alcohol. Dreams and fancies are experienced. A sudden cut or other stimulus is not actually painful, but it tends to arouse the patient's emotions. Reflexes are easily excited, the pupil is partly contracted. This stage can be employed for a momentary operation, opening a superficial abscess, an easy extraction of a tooth,

the breaking down of a simple adhesion. During it the pains of labour are only partly felt and are not markedly weakened thereby.

(3) *Rigidity.*—The patient is unconscious, but is thrown by over-excitability of the central nervous system into a state of muscular rigidity with irregular movements, the latter ceasing before the muscular tension is relaxed. The rigidity varies in degree, in the jaw, in a limb, in the abdominal wall, in which last it may persist long after complete relaxation in the jaw and limbs. Most of the reflexes are retained or even exaggerated. Coughing, swallowing-movements, frothing at the mouth, retching, and vomiting tend to arise. Ankle clonus may be obtained. The heart and respiration are more or less irregular on account of the muscular movements. The pupil contracts further.

(4) *Muscular relaxation* (corresponding to deep sleep) *or surgical anæsthesia.*—There is muscular relaxation, which includes that of the soft palate and abdominal muscles, but not necessarily loss of the laryngeal reflex which closes the glottis on irritation, nor of the sphincter ani, but the other reflexes, conjunctival, patellar, etc., are abolished. The pupil is contracted. The heart and respiration are regular and normal, the respiration softly snoring, the pulse tension normal, or slightly weakened by chloroform.

(5) *Deep coma*, with signs of weakening of the central nervous system. The respiration is deep and stertorous, with a variable amount of cyanosis, but may tend to become shallow and periodic. The heart-rate is unaltered, but the pulse-tension is sensibly less, and the face and lips are pale or livid. There is loss of the glottis reflex and relaxation of the anal sphincter. This is a dangerous state, in which the patient passes from deep sleep into one which borders on dying, and which cannot exist but for a short time. Meanwhile, there may be a quickening of the heart-rate and a marked weakening of the pulse.

(6) *Dying.*—The pupil fully dilates, the eyelids widely open, the respiration becomes superficial, fluttering or gasping, then stops. The pulse is lost at the wrist and the face and lips become deadly pale, or if previously blue, the face is shrunken ; the cardiac sounds are faint, then lost, and after a few irregular beats the heart stops.

Choice of an anæsthetic.—The stage of analgesia may be obtained by a short administration of nitrous-oxide gas, by stupefying the patient with a few breaths (about ten) of ether, or by giving chloroform very diluted with air, *e.g.*, during labour. The safest and best anæsthetic for general use is ether, preceded by nitrous-oxide gas. Chloroform is the only possible anæsthetic for hot countries whenever the temperature is above 80° F. ; also in war it is much more portable than ether. It can be safely given to children. Ether and chloroform vapours are conveniently combined, ether being given first, followed by chloroform, or alternated at the pleasure of the anæsthetist, or the drugs may be previously mixed. The stage of

deep anæsthesia corresponding to coma can only be induced for a short time, *e.g.*, when exploring the peritoneal cavity, or stretching the sphincter ani. It is obtained with the least risk by giving ether as concentrated as possible; if chloroform is used it must be given with great care, the patient not being touched by the surgeon until the desired stage is reached.

Preparation of the patient.—Artificial teeth must be removed, and the mouth should be inspected for any special difficulties. In edentulous people it is difficult to keep the lips and gums apart. When the tongue tends to fall back it must be dragged forward by forceps, also by elevating the chin, but if there is any great difficulty a ligature should be passed through the tip. A dental prop is inserted in operations on the mouth when it is not proposed to obtain complete relaxation of the jaw. Generally it is best to place the patient on the operating table before commencing the administration, rather than starting it with him in bed, except when he cannot be moved without great pain.

Posture of the patient.—Commonly this is dorsal, with the head turned to one side. The lateral position is necessary for operations on the opposite side. The lateral prone position is employed by many for operations on the mouth and throat, *e.g.*, adenoids, so that blood and mucus can easily escape from the mouth by the lower angle. The sitting or partly reclining posture is chiefly employed by dental surgeons. Operations on the tongue, jaw, and fauces are often done with the head and shoulders much raised. Sitting in a chair with the head bent forwards is employed by some for the removal of adenoids. The hanging head, the head drawn over the upper end of the table, has the great advantage that all blood and mucus must escape by the mouth and nose, but the objection to it is the excessive amount of venous hæmorrhage. The prone position, the shoulders and head being partly supported by pillows and turned to one side, is a difficult one for the anæsthetist; it is employed for operations on the spine and loin, and with the legs hanging down for operations on the rectum and buttocks. The lithotomy position, and also the Trendelenburg position, in which the pelvis is raised, must be accompanied by a corresponding lowering of the head and shoulders, so that these are brought into a straight line with the rest of the trunk. Otherwise the patient is doubled up, and respiration hindered.

Food beforehand.—A general anæsthetic should be administered on an empty stomach. To avoid discomfort to the patient, or even faintness from want of food, an operation is best timed to correspond with a patient's usual meal-time, so that the interval usually occurring between one meal and the next is not exceeded. Babies and weak patients on a fluid diet should not be kept for longer than two hours without food. Six hours after a light meal is quite long enough for an ordinary adult to wait. If the operation is to take place early in the morning, the patient may have some hot fluid,

soup, tea, cocoa, or milk and water, on waking, some two or three hours beforehand, but this, except in weak and exhausted subjects, is not necessary, and certainly increases the chance of vomiting.

Nitrous-oxide gas, being freed from irritating oxides and chlorine, and being kept in cylinders, does not get mixed with air and cause irritation or excitement. It is most readily given through some modification of Clover's inhaler so that it can be gradually replaced by ether if desirable. Dr. Hewitt mixes it with oxygen in order to prevent cyanosis and convulsive movements from asphyxia, but much skill is required to attain the proper combination, or otherwise the oxygen excites. Other anæsthetists reach this end by lifting the face-piece as cyanosis supervenes, or by filling the Clover's bag with air. Nitrous-oxide gas may also be given straight from the bottle through a tube in dental and nasal operations, but anæsthetists generally take off the face-piece to allow of the operative procedure. The gas must escape slowly from the bottle or it will freeze and burst the tube. The Clover's face-piece should be held firm over the face, so that nothing but gas shall be inhaled. Some allow the expired air and gas to escape by a valve, but then more gas is required. No harm seems to ensue from re-breathing the expired air, especially when following up the gas with ether. In fact, with many patients the mixture of gas and the carbonic acid of the expired air is a great advantage; the patient can soon begin to breathe ether, and rapidly goes under with little rigidity and no struggles. In using gas alone, the administration is continued until the reflex closure of the eyelids on pinching is lost. Before this stage no marked cyanosis need occur, as it is obviated by just raising the face-piece once, or by Dr. Hewitt by giving a little more oxygen. Supposing the administration now to be interrupted, the patient has on the average about forty seconds of anæsthesia during which short operations can be done. Then the gas can again be given, and the subsequent period will be shorter, the anæsthesia altogether lasting two or three minutes. Some patients can be kept continuously for ten minutes or more under gas in the rigid stage, giving it through a nasal tube, whilst some air enters by the mouth; but there is often no advantage from the method, for although patients rapidly recover consciousness, they may be just as sick afterwards as if ether had been used to produce the same stage of anæsthesia, whilst rigidity may be troublesome. A patient to whom nitrous-oxide gas is to be given alone must have had no food for two hours, and then only a light meal. The collar, stays, and waistband must be undone, and the patient can then be seated upright, or only partly reclining. If the gas is only given once or twice, recovery follows in a minute after some dreaming or emotional excitement. Hallucinations have occasionally followed.

Nitrous-oxide gas should not be followed directly by chloroform, but ether should be interposed for a little while. It is absolutely fatal to return from chloroform to nitrous-oxide gas.

Ether.—The only ether which should be used to obtain general anæsthesia is the æther purificatus (B.P., sp. gr. 0·722—0·720). Rectified ether obtained from methylated spirit is not quite so good. Absolute methylated ether (sp. gr. 0·717—0·719) is only suitable for local anæsthesia, and methylated ether (sp. gr. 0·730) for cleansing the skin, etc.

The ether should be given through a Clover's or similar inhaler, preceded by nitrous-oxide gas, until the ether can be respired easily when turned on slowly. Meanwhile the face-piece must be held firmly to the patient's face, for if air is admitted the patient will start swallowing-movements or coughing and struggling. The best way is to keep the face-piece tightly on until the breathing becomes stertorous, when a breath of air may be allowed. Otherwise one may have to go back and give some gas, or mix some inhalations of chloroform with the ether. Strong, and especially alcoholic, patients require a concentrated administration of ether mixed with expired air, otherwise it is very troublesome to get them under. On the other hand, all weak, exhausted or collapsed patients can be rendered anæsthetic and kept under with an extraordinarily small amount of ether. When once under, the inhaler may be turned back to mark 1, with frequent inspirations of air, or the administration can be intermitted for considerable periods during the middle of the operation, a little more being given to prevent the patient from coming round whilst the sutures are being inserted. The mouth-piece requires to be well sponged or otherwise sterilised, and the bag emptied and sponged between each administration. Before being put away, the rubber must be allowed to dry in the air.

To get rid of the ether and the nausea caused by it, hot water to which bicarbonate of soda (grs. x.—xv. ad ℥j.) may be added, or sips of hot coffee may be given, or the mouth may be washed out with a teaspoonful to a wineglassful of diluted lemon juice, vinegar, or eau de Cologne. For continuous vomiting morphine and atropin may be injected hypodermically.

Chloroform is the most potent and therefore the most dangerous anæsthetic. Hence an excess is often administered. The dosage cannot be measured by the amount of chloroform poured from the bottle. An excess may be taken in by one inspiration enough to arrest the heart.

It is best administered by the open method—on the corner of a towel drawn through a closed safety-pin, on a square of two or three layers of lint held away from the face by the hand; the lint can be thrown away and the towel changed with each administration, so there is no question of special cleansing. Closed methods of chloroform inhalation should be avoided. Skinner's mask and Rendle's are much employed, but are not necessary, and are apt to be used again without being cleaned. For operations on the mouth, etc., the chloroform is blown through a tube from a Junker's bottle,

which should be so made that no stream of chloroform can be blown out whichever way the tubes are joined up. In any case the apparatus should first be tested to see that chloroform vapour only is expelled; one squeeze of the ball can otherwise send enough liquid chloroform down a patient's throat to poison him. A mouth-piece can be put on the end of the tube, and chloroform blown in.

Different ways of giving chloroform are recommended. Some pour on chloroform freely, and hold it so that the patient is anæsthetised in a few respirations, but great watchfulness is required, for the administration must at the precise moment be interrupted and some air allowed. It is well then to smear the lips with vaseline to prevent blistering. Some put the patient under very slowly, taking ten minutes or more about it, making him count after the administrator, whilst the chloroform is held at some distance from the mouth. On the whole, the best course to aim at is a continuous administration of a well-diluted vapour, so that there is no occasion to interrupt or to suddenly apply the chloroform. The vapour from a square of lint at a short distance from the face is estimated to be about 4 per cent.

When given during labour, a little chloroform is dropped on to wool at the bottom of a tumbler, but not enough to saturate the wool. It should not be administered until the true pains commence; the woman can then hold the glass to her mouth as the pain increases, but it should be removed before the end of a pain, for excess predisposes to uterine inertia and to post-partum hæmorrhage. The same method is used in cases of severe biliary and renal colic. A little more chloroform is required to quiet patients with eclampsia, strychnine poisoning, tetanus and delirium tremens, but a good deal of risk has to be run in such cases.

Chloroform dangers.—There are three danger signals, each of which must be looked for, because patients differ as to the one that first becomes prominent. Commencing dilatation of the pupil from the contracted position assumed as the anæsthesia is first induced; reduction in the pulse-tension as the chloroform commences to influence the heart muscle together with pallor of the lips; and superficial or irregular respiration. The administrator must never withdraw his attention for a moment, and then one of these signs will be noticed early. For lack of this, a patient's heart or respiration is commonly said to stop suddenly. An absolute suddenness is negatived by the experience of skilled anæsthetists, although it must be admitted that the above warning is sometimes very brief. Fortunately in the cases where the use of chloroform is essential, *i.e.*, in operations on the mouth and throat, also in hot climates, it is not likely that it will be given to excess. The deaths from chloroform have too often occurred to ill-prepared patients, on whom, in more than half of the deaths, dental or other comparatively trivial operations have been hastily undertaken. Ninety per cent. have

occurred in the first fifteen minutes of the administration. Advocates of the general use of chloroform have been said not to administer chloroform beyond the point at which the corneal reflex disappears, but in this stage, retching, coughing and abdominal rigidity are frequent.

Mixtures of ether and chloroform.—It seems best to practise the administration of ether and chloroform separately, and to alternate the one with the other as the exigencies of the moment require. But it is largely the custom to first mix the fluids. If so, this must be done shortly before use, as variations in the rate of evaporation quickly alter the composition of the mixture, which for administrative purposes should be regarded as diluted chloroform. It should not therefore be given in a closed inhaler. Skinner's mask or Rendle's inhaler, with large holes, are often used, but a square of lint suffices, and can be discarded at the end. "A.C.E." (alcohol 1 part, chloroform 2 parts, and ether 3 parts), or "C.E." (chloroform 2 parts, and ether 3 parts), are the general mixtures.

Anæsthetic difficulties.—Patients addicted to alcohol often require a large quantity of ether, and struggle much; a few inspirations of chloroform may then be given, going back to ether as soon as the patient breathes quietly. Bronchitic, obese, and aged patients with atheroma or chronic Bright's disease, must not be given much ether, but a sparing amount of chloroform should be administered until the tension of the pulse begins to fail, when a little ether may be given by the open method, with a return to chloroform upon the first sign of cyanosis. Patients, on the other hand, suffering from exhaustion and collapse, *e.g.*, intestinal obstruction, should be given only ether either by the open method, or by frequently removing the face-piece, and altogether as little as possible of the anæsthetic should be used.

Patients with an irritable pharynx from chronic inflammation, tobacco smoking, etc., must be put deeply under nitrous-oxide gas before turning on the ether. A patient suffering from laryngeal obstruction should be prepared ready for tracheotomy, and the surgeon should stand by with the knife. Then some nitrous-oxide gas alone is given until the patient is cyanosed, when the trachea is quickly opened and a tube inserted; thereupon some chloroform is blown in. Some give instead a little chloroform, but this often entails artificial respiration as soon as the tube is inserted, and meanwhile the heart is in danger. In such cases ether and the "A.C.E." mixture often cannot be respired at all.

Treatment of anæsthetic complications.—When one or all three of the above-mentioned signs of danger, dilatation of the pupil, fall of pulse-tension with pallor, and irregular respiration, appear rapidly, the patient is in danger of dying. Not that one of the signs may not exist throughout much of the operation without the need for more than anxious care; the patient may not breathe regularly, or

the pulse be throughout weak, or the pupil widely dilated. It is when these signs occur one after the other with suddenness, that they indicate threatened death. And if there is one sign more dangerous than the others, it is the rapid failure of the pulse at the wrist and pallor, which indicates an arrest, it may be irremediable, of the heart.

Immediately on these signs appearing the anæsthetic is taken off, the pillow pulled from the patient's head, and his mouth and throat sponged out, and the jaw well pulled up. This failing, the tongue is pulled out and rhythmically drawn on (Laborde's method) until he breathes. If pale and pulseless, the head is lowered below the trunk and the chest exposed. He may be going to vomit, and if there are movements of the diaphragm and abdominal muscles indicating this, the pharynx is again sponged to excite vomiting. If not, artificial respiration is begun, with the patient as much inverted as possible, *e.g.*, by the legs being bent at the knees over the shoulders of an assistant, but not so violently as to strain arms or bruise ribs. Oxygen inhalations may be valuable. The first movements of artificial respiration must be forcible expression, not only to expel the excess of the anæsthetic and mucus blocking the respiratory tract, but to partly squeeze the heart. When respiration has recommenced, similar treatment to that mentioned under *Shock* (p. 222), especially by saline infusion and strychnine injection, may be required. Alcohol and ether injections, if excessive, only add to the anæsthesia. Artificial respiration with inversion and rhythmic traction of the tongue are the only approved remedies under the circumstances to regain a rhythmic heart-beat. If there is any question of the upper respiratory tract being blocked, tracheotomy should be at once done, and after forcible expirations the chest may be well inflated through the tracheotomy tube. If the heart has stopped or is only fluttering, subcutaneous injections can obviously do no good, for the circulation is arrested, and electric currents, if they do anything, would further arrest the heart by stimulating the vagus. When the heart has been just arrested in animals by chloroform, a rapid opening of the chest and squeezing of the heart has made it start again. And this heroic measure has been adopted in man, with the result that the patient has been kept alive for some hours, with a re-established circulation, but no spontaneous respiration; artificial respiration had to be continued. During an abdominal operation Mr. Arbuthnot Lane squeezed the patient's heart through the intact diaphragm so as to make it start again and this is doubtless the way this expedient should be tried, not by the opening of the thorax.

It should be remembered that ether is inflammable, and therefore no naked light must be brought near. Chloroform in contact with a naked flame in a small room, whilst not inflammable, decomposes into phosgene, and then into hydrochloric acid, and so causes irritation.

Pneumonia following operations is generally attributed to the anæsthetic, especially to ether after throat, breast and abdominal operations. However, abdominal operations under local anæsthesia have been followed by pneumonia in as many cases as after ether. In breast cases the exposure may have a good deal to do with it. Undoubtedly in throat cases it is avoided by protecting the respiratory tract from blood during the operation, and from septic inhalation afterwards.

Statistics ranging over a great number of cases by administrators of all sorts, show that ether is at least five times safer than chloroform; besides which, the deaths under chloroform have often been in relatively young and healthy people, and occur on the operation table, whilst those from ether have been in patients suffering previously from various complications, and occur some time afterwards.

Local anæsthesia.—*Cocain hydrochloride* is the most rapid and powerful local anæsthetic, but it cannot be used in amounts of more than half a grain at a time where likely to be rapidly absorbed without some risk of poisonous symptoms supervening. The patient becomes faint, cyanosed, has peculiar sensations, and tends to vomit. He should then lie down and be watched, a little brandy or sal volatile being given. In more serious cases of threatened respiratory and heart failure, amyl nitrite is inhaled, strychnine injected, coffee given by the stomach or rectum, or artificial respiration carried out. But these risks should not be run. A $\frac{1}{2}$-grain (0·032 grm.) dose should not be exceeded.

It is best employed in a solid form, "tabloids" or "soloids," as it is apt to grow a fungus and decompose in solution. A 1 per cent. solution, or less, is used hypodermically. A 2 per cent. solution is employed for rendering the cornea anæsthetic, a 2 to 4 per cent. for urethral and bladder injections, a 5 to 20 per cent. solution for rendering the mucous membrane of the nose or larynx anæsthetic.

Eucain hydrochloride is less active, slower in its action, but less poisonous than cocain. If used alone it may be employed in double the doses of cocain, but is often simply added to the cocain solution in equal doses.

Hypodermic injections of *cocain, eucain and morphine* have been used in saline solutions.

Dr. Schleich's formulæ are :—

	Strong.	Medium.	Weak.
Cocain hydrochloride ...	2	1	0·1
Morphine hydrochloride ...	0·25	0·25	0·25
Sodium chloride	2	2	2
Water, sterilised	1000	1000	1000

The medium is generally used, the weak for deep infiltration, the strong only in sensitive areas. The hypodermic needle is pushed *under* the skin in the line of the incision and withdrawn slowly, injecting a drop each millimetre or two, or it is injected *into* the

skin until a wheal is raised by keeping up pressure on the piston. After incising the skin the needle is pushed into the deeper structures, which are infiltrated before making deeper incisions.

Intra-arachnoid injections. — Bier's method. — Prof. Reclus reports that this method is responsible for three to four deaths in every thousand, which makes it much more dangerous than any general anæsthetic. No advantages and many drawbacks are evident. We have neither used it nor advise its use. Whilst in operations on the lower abdomen and extremities complete local anæsthesia may be obtained, the patient is fully conscious, and as a direct result of the injection may suffer from faintness or severe collapse with vomiting. In other cases the anæsthesia is very imperfect. Its use for operations higher up on the trunk is prevented by the danger of paralysing respiration.

Freezing by chloride of ethyl or ether spray is only of service for very superficial punctures. (See p. 27, *Incision of Abscesses.*)

SECTION III.

Injuries of Special Tissues.

INJURIES OF BONES

Fractures.—A fracture may be defined as a sudden solution of continuity in a bone.

The causes of fracture are injury or traumatism and disease, causing pathological fracture; or short of actually causing it, disease may be regarded as a predisposing cause to fracture from slight injury. The exciting causes of traumatic fractures are external violence or muscular action. Bones are most resistant to traction, next to pressure; they are less resistant to flexion or bending, and least of all to torsion. (*a*) *External violence* may be direct or indirect. In fracture from *direct* violence the bone is broken at or near the spot where the violence is applied. Such fractures are usually attended with more serious consequences than fractures from indirect violence, since the soft parts are, as a rule, much injured, and the fragments comminuted or fissured, and, perhaps, driven into important organs, as the lung in fracture of the ribs, or the brain in fracture of the cranium, etc. In *indirect* violence the fracture occurs at a distance from the spot where the violence is applied, as, for instance, a fracture of the clavicle from a fall on the arm. The bone usually breaks at its weakest spot, and the fracture may be rendered compound from the fragments, which are often much displaced and sharp and irregular, being driven through the soft parts. Fracture from indirect violence is most common in the bones of the extremities, and the base of the skull. (*b*) *Muscular action* is not so common a cause of fracture as external violence. Its commonest occurrence is in the patella, occasionally in the arm, especially when combined with twisting.

Pathological fractures and fractures from diseases, also forming predisposing causes to fractures from slight violence. In this category may be enumerated most of the diseases of bone, senile atrophy, atrophy from pressure or disuse, fatty degeneration, rickets, congenital defects, osteomalacia, osteomalacia carcinomatosa, general paralysis, locomotor ataxy, tuberculous foci, syphilitic gummata, caries and necrosis, hydatid cysts, and malignant growths; in brief, any condition rendering the bone unusually fragile, to which may be added the peculiar and inherited condition of the bones (*osteo-psathyrosis*) rendering them liable to multiple spontaneous fractures. To these diseases may be added the results of past injuries

impairing the usefulness of a limb, fractures, dislocations, ankylosis of joints, fixation of tendons, and nerve-lesions.

Varieties of fracture.—A fracture is said to be *simple* when subcutaneous and uncomplicated, with the skin covering it not broken; *compound*, or open or complicated, when a wound through the skin and soft parts leads down to the seat of the fracture. Whether simple or compound, fractures are further spoken of:—1. According to their extent, as:—*complete*, when the bone is broken quite across; *incomplete* or *greenstick*, when partially broken and partially bent; *comminuted*, when broken into several pieces; and *multiple*, when two or more distinct fractures occur in the same bone, or in different bones. 2. According to the condition of the fragments, as:—*impacted*, when one fragment is driven into another; *fissured*, when there is a mere crack through the bone without displacement; *depressed*, when one fragment is pressed in below the surface, as in some fractures of the cranium; *punctured*, when there is a small perforation with driving inwards of the fragments; and *splintered*, when only a fragment of bone is chipped off. 3. According to the line of fracture, as:—*transverse*, *oblique like the mouth-piece of a flute*, *spiral*, *longitudinal*, Y- or T-*shaped*, and *stellate*, terms which sufficiently explain themselves. A fracture, moreover, is said to be *complicated* when associated with other injuries, such as dislocation of the same bone, rupture of the main artery of the limb, injury of an adjoining internal viscus as the brain or bladder, implication of a large joint, etc. Further, a fracture is spoken of as *intra-uterine* when it occurs as the result of external violence or uterine contraction before birth, or as *congenital* when it occurs during birth.

Displacement of the fragments, especially in the bones of the limbs, commonly occurs, except the fracture be transverse, when, as in the case of the tibia, there may be little or none. The causes of the displacement may be enumerated as:—1. The violence producing the fracture; 2. Careless handling by bystanders; 3. Injudicious movement on the part of the patient; 4. The weight of the lower fragment; and 5. Muscular spasm acting on the upper fragment. The amount of displacement will depend in part on the direction of the line of fracture, and in part on whether the periosteum is or is not torn. Thus the displacement is usually considerable when the fracture is oblique, insignificant when transverse, especially if the periosteum is intact. The displacement is spoken of as an *angular*, *lateral*, *longitudinal*, and *rotatory* one, according to the direction which the fragments take to each other.

Signs.—Before examining for fracture, an accurate history of the accident should, if possible, be obtained, since much light may thus be thrown on the nature of the injury. The clothes should then be carefully removed, and the parts handled tenderly, lest a simple fracture be converted into a compound by a sharp fragment being

driven through the skin. Thus, in the case of the leg, the boot should be cut off, the trousers ripped up the seam, and the stocking split with scissors. The injured side should always be compared with the sound side. The general signs of fracture are:—1. The sensation of a sudden snap or giving way of the bone experienced by the patient; 2. Pain; 3. Impairment or loss of function; 4. Alteration in the shape of the part; 5. Swelling, and, on examination, 6. Preternatural mobility; 7. Shortening; 8. Crepitus. No one of the above signs alone, except *crepitus*, is absolutely diagnostic of fracture; and crepitus itself, when the fragments are impacted and when the fracture is of the greenstick variety, may be absent, or may be simulated by joint-crepitus, effusion into the sheaths of tendons, emphysema, and by the grating of osteophytes in chronic osteoarthritis. It is prevented by muscle or fibrous tissue between the ends. True crepitus, however, having been once felt, can hardly afterwards be mistaken; it is readily distinguished from false crepitus by its harsher and more grating character. The *shortening* may be natural or due to some previous injury or disease, as a former fracture, osteoarthritis, etc.; shortening also occurs in dislocation. *Increased mobility* may not be present, as when a fracture is firmly impacted. *Pain* may, of course, occur from causes other than fracture; it may often be elicited in fracture when crepitus cannot be obtained. *Swelling, loss of function and alteration in the shape* of the part may be present in other injuries, but are useful signs in some forms of fracture. Too much weight, it need hardly be said, should not be given to the patient's *sensations*, as a snap or feeling of the bone giving way may occur in rupture of a tendon or ligament.

Constitutional symptoms, depending upon shock if the injury is severe, or upon hæmorrhage if much blood has been shed either externally, as in compound fracture, or into the pleural cavity in fracture of a rib, may, of course, be present. But in addition to these, there is generally at the end of twenty-four hours or so some slight rise of temperature lasting for a few days (*fracture fever*), due to the absorption of tissue products, and occasionally *changes in the urine*, such as a trace of albumen, fat in the form of an emulsion, and an excess of urobiline, due, it is believed, to the breaking up of the medulla and extravasated blood at the seat of fracture, and the excretion of their products by the kidneys. The constitutional symptoms that may attend compound fracture are described under that head.

The *diagnosis* is often difficult, especially in limbs:—1. When the fracture is near, or extends into, a joint, owing to effusion of blood or synovial fluid into the joint-cavity. 2. When there is great extravasation of blood, or later, effusion of inflammatory products about the fragments. 3. When the fracture is transverse, and there is no displacement, especially if the fragments are held in

position by a companion bone, as the fibula in fracture of the tibia. 4. When the fracture is subperiosteal. In the cranium, a simple uncomplicated fissured fracture cannot be diagnosed. In doubtful cases of fracture much aid is obtained by anæsthetising the patient and by means of the *x* rays, due allowance being made for deceptive appearances.

How to obtain crepitus.—Grasp the limb firmly above and below the suspected fracture, and when there is shortening, make extension to bring the rough surfaces into contact. Then gently attempt to move the lower on the upper fragment. Having once assured yourself that crepitus is present, desist from your manipulations, as they not only give the patient pain, but injure the soft parts. In some cases, as in fracture of the neck of the femur, where the nature of the

FIG. 92.—Diagram of the fragments a few hours after simple fracture. The periosteum is torn and ragged, and separated from the bone for a slight distance above and below the fracture. Blood is extravasated between the fragments, in the medullary canal, and in the periosteum and other soft tissues surrounding the fracture.

FIG. 93.—Diagram of the process of repair in simple fracture. A. Ensheathing callus; B. Internal callus; C. Permanent callus. Commencing ossification of the ensheathing callus is indicated by the darker shading at the angle between the periosteum and the bone.

injury from the presence of other signs is quite obvious, crepitus should not be sought lest an impacted fracture be rendered non-impacted and afterwards remain ununited, or the periosteum uniting the fragments be torn, and a like result ensue.

Union of fractures.—The method of union by callus is similar to that which takes place in the healing of a wound of the soft parts by first intention. Blood is at first extravasated between and around the fragments until the torn vessels are occluded by clot. Within a day of the injury there begins a simple inflammation from the torn vessels of the bone, periosteum and surrounding soft parts, viz., an emigration of leucocytes and an exudation of fluid. Following upon this commences repair, the cells of the osteogenetic layer of the periosteum begin to proliferate, so also to a less extent do the bone corpuscles and surrounding endothelial and connective-tissue cells, and these cells gradually infiltrate and remove the clot, and collect to form the

temporary callus. From the second day onwards cells, phagocytes, are seen containing remains of leucocytes, red corpuscles and tissue fragments. In a simple normal fracture there is no emigration of leucocytes or pathological exudation after six days. The mass of soft, red, gelatinous granulation tissue is composed then of tissue-cells, derived from the periosteum, bone and connective tissue, which are similar to the fibroblasts in a wound with this addition, that the cells, especially those from the periosteum, have osteogenetic properties, are *osteoblasts*. Between these cells newly-formed capillaries grow in from the vessels in the Haversian canals, periosteum, and neighbouring connective tissue. The formation of new bone in the callus is that of the formation of bone in membrane. There is, in addition, a variable amount of a firm, gelatinous intercellular substance, which, when in considerable amount, distinctly separates the cells and gives a bluish appearance to the naked eye, and is called cartilage. It has been seen especially in children and animals. Hence there have been various statements in the past as to whether a fracture unites by ossification in membrane, or sometimes by ossification in pre-formed cartilage. It would appear that with the ends of the bone in good apposition, kept at rest, and with a normal rate of callus-formation, the process is one entirely of formation of bone in membrane, without any pre-formed cartilage, even in children or animals. But with inexact apposition, movement of the ends and a delayed formation of callus, islands or masses of cartilage may appear. This affords an explanation of the appearance of cartilage in the callus of animals and rickety children.

Callus is found (1) replacing the periosteum, and extending for some distance around the bone above and below the line of fracture, forming a spindle-shaped tumour, by which the ends of the fragments are surrounded, as it were, with a ferrule (*ensheathing or periosteal callus*, Fig. 93, A); (2) replacing the medulla for some little distance up and down the medullary canal (*internal or endosteal callus*, Fig. 93, B); and (3) between the ends of the fragments (*permanent, intermediate or definitive callus*, Fig. 93 C). The ensheathing callus and internal callus are gradually organised into fibrous tissue, becoming harder and firmer. The outermost layers of the fibrous tissue into which the ensheathing callus is thus converted form a new periosteum. Ossification of the ensheathing callus now begins (twelfth to fifteenth day)—generally in the angle between the periosteum and the bone, and extends along the surface of the bone, and also along the surface of the ensheathing callus beneath the new periosteum, till the upper and lower layers of ossifying callus meet opposite the line of fracture. Ossification of the internal callus goes on in a similar way, but begins a little later. The permanent callus, as soon as the ends of the bone are thus fixed by the ensheathing and internal callus, also undergoes ossification. The ossified callus is at first very vascular and porous, and can be easily stripped off the old

bone, but later it becomes hard and dense, through the formation of new bone in its blood-spaces, and intimately connected with the old bone beneath it. Finally the ensheathing callus and internal callus, having discharged their functions, are gradually absorbed, and if the fragments have been held in good apposition no sign of the fracture may ultimately remain. Such consolidation of the bone may be said to occur in from four to six weeks, or even eight in the case of the lower extremity, but many months must elapse before repair can be spoken of as complete.

The process of absorption of the temporary callus consists, in the first place, of removal of the lime salts, leaving fibrous tissue, which in its turn undergoes absorption, so that muscles, tendons, and nerves involved in the callus become freed and regain their function.

FIG. 94.—Fracture of the femur with overlapping fragments to show rounding off of angles, and restoration of medullary canal by absorption of intervening bone. (St. Bartholomew's Hospital Museum.)

Whenever the bones are not in exact apposition, a modelling process occurs which may transform much of the internal structure of the bone. The course of the septa, whether in persisting ensheathing callus or in the bone itself, takes a changed direction in accordance with the altered transmission of weight through the bone and the different angle at which the muscles pull.

Where the ends of the fragments overlap, the ensheathing callus fills up the angles (Fig. 94); and while the open end of the medullary canal in each fragment is thus closed, its continuity through the bone is restored by the absorption of the intervening walls of the contiguous and overlapping fragments (see also Fig. 94). Where the fragments are not in contact, the intervening space becomes filled with the ensheathing callus, which is then sometimes called *interposed callus*. Where the fracture is comminuted, the splintered fragments become glued, as it were, together, and to the main fragments by the ensheathing callus formed from the granulation tissue in which they become surrounded. When the fragments are in good apposition, and are kept at rest, little or no ensheathing callus is formed; but when there is much displacement, or rest is impossible as in a fractured rib, or difficult to obtain as in a fractured clavicle, a considerable amount is produced. In children, even when the parts are kept at rest and in good apposition, the formation of much ensheathing callus is the rule.

Treatment.—Here only the indications for treatment will be pointed out. The particular methods will be given under *Special Fractures.*

A. *Treatment of simple fracture.*—The indications are—(1) to reduce the fracture, that is, to place the fragments in apposition, so as to restore as far as possible the bone to its normal shape; (2) to keep it in this position by properly applied apparatus till firm union has occurred; (3) to promote the restoration of the normal functions of the part; and (4) to attend in the meanwhile to the general health and comfort of the patient.

1. The *reduction*, or as it is popularly called, the setting, of the fracture, should not be undertaken until the apparatus into which the limb is to be permanently placed is ready; but the fragments should be temporarily fixed so as to prevent further injury, such as a sharp fragment being forced through the skin. Thus, in the case of the lower extremity, the injured limb may be bound to the sound one, or secured by a handkerchief to an impromptu splint, such as an umbrella, walking-stick, or rolled-up newspaper; or if the patient is not seen till he is already in bed, the limb may be placed between sand-bags or wrapped in a pillow. As a general rule, the fracture should be reduced as soon as possible, since if the reduction is delayed the muscles become contracted and resistant, and the soft parts bound together by inflammatory adhesions, whilst there is always a danger of laceration of the surrounding tissue by the sharp fragments; where, however, there is much swelling, the part may, under some circumstances, remain wrapped in a pillow or secured by sand-bags till the swelling has subsided. When the fracture is transverse, the fragments will, as a rule, be but slightly displaced, and little as regards reduction will be required. In other instances, as when the line of fracture is oblique, considerable trouble in bringing the fragments into apposition may be experienced. The chief obstacles to be overcome are (1) the contraction of the muscles, which are thrown into action by the irritation of the fragments; and (2) the impaction of the fragments, or the interposition of muscle or tendon between them. The splint or other apparatus being in readiness, extension in the case of fracture of a limb should be made on the lower fragment, preferably, as a rule, through the intervention of the joint below. Thus, in fracture of the forearm or leg, extension should be made from the hand or foot respectively, whilst counter-extension is applied at the same time to the upper fragment, also preferably through the joint above. Whilst steady traction is thus being made, the surgeon should gently manipulate the fragments, and he should not rest satisfied till the symmetry of the part has been as far as possible restored and the limb is found, both on inspection and measurement, to correspond as near as may be with the opposite side. In this position the parts should be held till the apparatus for permanently fixing them has been applied. Where great difficulty is experienced in reducing the fracture owing to muscular spasm, the limb should be flexed or placed in such a position as will tend to relax the opposing

muscles, or if this does not suffice an anæsthetic must be administered. To ensure complete reduction some surgeons reduce all fracture of the limbs under an anæsthetic and fix the fragments in splints or plaster of Paris before the patient regains the power of muscular contraction. At times the subcutaneous division of a tendon may become necessary before the fracture can be reduced. In impacted fractures, as of the neck of the humerus or femur, or at the wrist, it is now deemed advisable to liberate the fragments, as union after impaction results in a deformed and largely useless limb. The special methods of reduction which may be required for certain fractures will be given under *Varieties of Fracture.*

2. *To keep the fragments in apposition* till union has taken place, numerous contrivances have been invented. They may be said to consist of splints, cradles, fracture-boxes, bandages hardened by plaster of Paris, silica, paraffin, glue, or gum and chalk, and such material as wire gauze, gutta-percha, poroplastic felt, and leather, moulded to the individual case. In oblique fractures, and fractures near joints, where the ends of the bone cannot be retained completely in apposition, an incision should be made down to the bone and the fragments secured by wiring or by screws, either immediately or after a few days.

The *method of applying splints* will be better learnt by three months' dressing in the wards than by any verbal description. The points that should be chiefly attended to are :—1. The splints should be well padded. 2. Pressure should not be made over points of bone. 3. Strapping or bandages should not be put on too tightly. 4. Circular constriction of the limb should be avoided. 5. The splints where possible should reach beyond both the joint above and the joint below the fracture. 6. The fracture should not, as a rule, be covered with the bandage. 7. The patient should be seen within twenty-four hours after the splints have been applied, as swelling of the part is apt to occur, and the bandages thus become too tight. 8. The part having once been properly secured in splints should not needlessly be disturbed. 9. Should the fragments become displaced from spasm of the muscles, steady extension as by a stirrup, weight, and pulley will usually overcome the difficulty. 10. The part below the fracture may sometimes be bandaged with advantage to prevent œdema, or at any rate the limb may be raised.

After the splints have been applied, if the surgeon has any doubt as to the fragments being in proper apposition a skiagraph should be taken, with the part in the splints. If the reduction does not appear to be satisfactory the splints should be removed and the fracture re-set. The time the splints should be kept on varies greatly, and will be stated under each individual fracture. On their removal the limb is by some surgeons kept at further rest for a variable time in a plaster-of-Paris, gum and chalk, or other

form of stiff bandage till complete consolidation has taken place. Hitherto splints have no doubt been often kept on too long, with the result that atrophy of muscles, stiffness of joints, formation of adhesions, etc., have taken place.

If the fracture is not severe, it may be safely placed at once in a plaster-of-Paris bandage or plaster-of-Paris splints (*Bavarian splints, Croft's splints*). If this or other similar material is used, the limb should be well padded with cotton-wool, the toes or fingers left exposed, the joints above and below included in the bandage, and the limb subsequently raised. The plaster of Paris must be dry, finely powdered, and be well rubbed into the bandages. Salt (ʒss. ad Oj.) quickens the setting, gum mucilage (plaster 1 lb., gum mucilage ʒj., water ʒviij.) delays it. The patient should be visited a few hours after the plaster of Paris has been applied, so that should the circulation have become impeded from swelling of the limb, the plaster bandage may be removed before any serious damage has had time to ensue. The indications for at once removing, or for loosening the bandage by cutting it in places are:—1, much pain; 2, swelling; 3, numbness; and 4, signs of obstructed circulation in the fingers or toes. A tight bandage, it should be remembered, is more dangerous in the upper than in the lower limb, because in the former most of the venous return is by the superficial veins. After the case has become hard it may be cut down in front and behind by a saw, or a string is laid under the plaster which serves to draw a hair-saw through, and then the plaster can be cut through from within outwards. The two halves are kept fixed by webbing and buckles or a bandage. Should the bandage become loose, it must of course be removed, and re-applied. By some surgeons the plaster splint in the case of the leg is so applied and strengthened by strips of metal that the weight of the body is transmitted through the splint from some prominence of bone above the fracture to the ground below, and the patient is allowed at once to walk about. The slight rubbing of the fragments in the movement of the limb is believed to promote union, and the wasting of the muscles from the disuse following the ordinary treatment is avoided. This method, which is known as the *Ambulatory*, has been much employed on the Continent and in America, but is unsatisfactory, for there is not enough supervision.

3. *To promote the restoration of the normal functions of the part*, physiological after-treatment is required. It has often been found after the apparatus has been removed, especially if the fracture was near a joint, that the joint is stiff, the tendons more or less glued together, and the muscles wasted and atrophied. Under these circumstances, shampooing, massage, electricity, friction with stimulating liniments, and passive movements of the joints must be sedulously employed; but it is better to prevent such troubles occurring by resorting to massage and passive movements much

earlier than has hitherto been the practice. Massage may be begun with advantage after the first few days, except in fractures of the femur and humerus, and is especially useful in fractures involving joints. Indeed, massage from the first is recommended by Lucas Championnière in fractures of this class. If undertaken thus early it ought to be done with extreme gentleness, since whilst blood-clot still remains unabsorbed about the fragments a displacement of a portion of a clot in a vein may lead to pulmonary embolism, and rough handling may cause suppuration. When the fragments are projecting close under the skin, or blebs have formed over the seat of fracture, as also when the fracture is compound, massage can hardly be employed. Every fracture requires an exercise of judgment, not the blind observance of some rule. The splints may be removed daily and massage applied, or in some the fractured limb may lie on a pillow or in a sling and be massaged daily from the first (see *Special Fractures*).

4. *The general health and comfort of the patient* should not be neglected. Thus if he is confined to bed, boards should be substituted for the ordinary webbing or steel laths of the bedsteads; the sheets should be kept smooth; and bed-sores guarded against by the use of water-cushions and by hardening the skin over prominent points of bone with spirit lotions. Old people should not be kept too long in bed, lest passive congestion and hypostatic pneumonia of the lungs occur. The general health should be promoted by attention to the secretions, regulation of the diet, and administration of sedatives to relieve pain and promote sleep.

Ununited fracture and false joint.—An *ununited* fracture is one in which the fragments are either totally ununited or merely bound together by fibrous tissue. Some fractures, such as transverse fractures of the patella, and fractures extending into joints in general, seldom or never unite by bone, but remain merely bound together by fibrous tissue, unless fixed by suture.

The condition of the fragments in an ununited fracture varies. The fragments may be completely separated, with the ends rounded off and the medullary canal closed; or they may be bound together by long pliable bands of fibrous tissue permitting of considerable movement, or by tough fibrous bands allowing of but very little, or by a fibro-cartilaginous material—a kind of ensheathing callus. The last condition, however, should be regarded as an example of *delayed union*, rather than as one of permanent ununited fracture.

A *false joint* or *pseudarthrosis* is an ununited fracture of some standing in which the ends of the fragments are rounded off and eburnated, or covered with a layer of fibrous tissue or fibro-cartilage, and enclosed in a strong fibrous capsule formed by the condensation of the surrounding soft tissues (Fig. 95). A fluid resembling synovia has occasionally been found within this capsule. A false joint may resemble a hinge or a ball-and-socket joint. The latter condition is

more common in fractures near the articular ends of bones, where rotatory as well as angular movement occurs; the former in fractures through the shafts of bones, where angular movement only is permitted.

The *Causes* both of ununited fracture and false joint are local and constitutional. The *local* are—1. The fragments not having been kept thoroughly at rest; 2. The fragments not having been placed in apposition in consequence of (*a*) muscular contraction; (*b*) the loss of a large piece of bone, as in compound fracture; (*c*) the intervention of a piece of muscle, tendon, or periosteum, or a foreign body, such as a bullet, between the fragments; and (*d*) the effusion of synovial fluid in the case of a fracture into a joint; 3. Necrosis of the end of one of the fragments; 4. The interference with the arterial supply of one of the fragments, as from injury of the medullary artery; 5. The poor supply of blood to one of the fragments, as in fracture of the anatomical neck of the humerus; 6. Defective nerve-influence, as sometimes occurs when the lower part of the spinal cord has been injured, with consequent disturbance of the trophic centres contained therein; 7. Malignant growths; 8. Osteomalacia.

Fig. 95.—False joint following fracture of the humerus. (St. Bartholomew's Hospital Museum.)

Constitutional causes.—Syphilis, tubercle, gout, Bright's disease, fevers, scurvy, anæmia, the cancerous cachexia, pregnancy, locomotor ataxy, old age, alteration of the patient's habits, alcoholism, and sudden deprivation of stimulants are all said to be causes of ununited fracture. No doubt any condition that lowers the vitality and consequent power of repair of the tissues has a tendency to delay union, but it seems doubtful if any of the above conditions except scurvy is in itself, apart from the local causes, sufficient to prevent the bone uniting. Paralysis agitans, in which there is great difficulty in keeping the patient quiet, and hence of immobolising the fragments by splints, etc., may also be regarded as a cause of non-union. The cause of the ununited fractures sometimes met with in children, in which in spite of every kind of treatment union cannot be obtained, is unknown.

Sometimes the callus, after having been formed, appears to be re-absorbed, the fracture being then spoken of as *disunited*. This is common in scurvy.

Treatment.—Constitutional as well as local treatment may be

required. In recent cases, *i.e.*, where the fracture is found ununited after having been kept in splints for the usual time—a condition sometimes called *delayed union* in contradistinction to ununited fracture—the splints should be re-applied, and in such a manner as to insure perfect immobility of the fragments, whilst the general health should be improved by every means in our power, and any constitutional taint, as syphilis, gout, etc., that may be detected, combated by appropriate remedies. Thyroidin has been recommended. If the patient has been accustomed to stimulants, and has been deprived of them, he should be allowed a moderate quantity. In some cases it may be expedient to put the fracture in an immoveable apparatus and let the patient get about on crutches. Should union still not occur, the end of the fragments should be rubbed together to excite some amount of inflammation, and splints or other apparatus be again applied. For such purpose chloride of zinc (10 per cent.) may be injected, or in compound fracture, plugs soaked in turpentine inserted. This failing, and in long-standing cases, two courses are open ; either to try to unite the fragments by some operative procedure, or to apply some form of permanent apparatus to hold them in position. The choice of these methods will depend to some extent upon the situation of the fracture, and whether it is of the nature of an ununited fracture or a false joint (a point that should be ascertained by skiagraphs), and upon the patient's age, constitutional condition, occupation, and rank of life. Thus in the case of an ununited fracture of the upper third of the femur in a patient of advanced age or of broken constitution an operation is attended with great risk to life, and for such some form of apparatus is better suited. But when the patient is young, or of good constitution, or his occupation is such that he cannot afford an apparatus and the continual expense of keeping it in good order, and especially where the fracture is in the shaft of the humerus, an operation should be undertaken. The older operations of subcutaneous scraping of the ends of the fragments, passing a seton between them, or driving in ivory pegs, which had all for their object the setting up of inflammation, and thereby inducing the formation of callus and ossification, proved either unreliable, inefficient, or highly dangerous, and are no longer employed. The operations now in vogue consist in cutting down on the fragments and fixing them together by wire sutures, screws, etc. (*a*) Where the site of the ununited fracture can be readily reached without much disturbance of the soft tissues, as in the shaft of the humerus, the ends of the fragments should be cut down upon, fully exposed, fitted together, trimming if necessary, and united with stout silver wire. Suturing, as formerly done, allowed of lateral and longitudinal displacement if the fracture was oblique or if the ends of the fragments were sawn off obliquely. Wille therefore advises that in oblique fractures two grooves (Fig. 96) be cut with a saw in the fragments,

the direction of the grooves being at a right angle to the fractured surfaces, and the fragments tied together with wire. Further, where both the fragments can be drilled vertically, he draws with a hook, invented for the purpose (Fig. 97), the wire through the

Fig. 96.—Wille's method of wiring the fragments in oblique fractures.

drill holes, divides it, and twists each half together (Fig. 98). Walsham has tried this method and found it answer admirably. Other surgeons, to obviate the lateral and longitudinal displacement, cut

Fig. 97 and Fig. 98.—Wille's method of wiring the fragments in oblique fractures.

the ends of the fragments in a zigzag manner so as to dovetail them together, but this requires rather delicate manipulation and cannot always be satisfactorily performed. In some cases the

Fig. 99.—Bone drill. The drill is made like a trocar and cannula. The end of the style projects beyond the cannula as a gimlet, whilst the square neck prevents it from being rotated except with the cannula. After boring through the bone the style is withdrawn, wire is passed through the cannula and the end held whilst the cannula is drawn back.

fragments can be more securely fixed together by aseptic metal screws. Care, however, is required in inserting them lest the bone be split. Senn advises the fixation of the fragments with bone ferrules (Fig. 100). Watson Cheyne and others use an aluminium plate fitted to the bone by nails or screws. (*b*) Where the site of

the fracture is deep, or the fragments overlap considerably, and the full exposure of the fragments and sawing off their ends would

FIG. 100.—Senn's bone ferrules for fixing the fragments in ununited fractures *in situ*. (After Senn.)

necessitate very extensive disturbance of the periosteum and soft parts, it is safer to merely expose the more prominent fragment,

FIG. 101.—Malunited fracture. (St. Bartholomew's Hospital Museum.)

FIG. 102.—Vicious union after fracture. (St. Bartholomew's Hospital Museum.)

bring the ends of the fragments together, and then drill two holes one above the other through each fragment, and fix them *in situ* by ivory pegs, nails, or metal screws. The irritation of the pegs, nails

or screws leads to the union of the fracture by the extensive formation of ensheathing callus.

After any of the above operations the wound should be closed, and if perfect asepsis is maintained the uniting material becomes encysted, and as a rule remains permanently *in situ* without giving rise to any inconvenience. It occasionally, however, becomes loose and requires removal after some weeks.

In ununited fractures with loss of substance from necrosis the gap may be filled by grafting a piece of bone between the fragments. The grafts may be obtained from a young animal, or from a limb immediately after amputation. Whilst being transferred the grafts should be kept at a temperature of 100° in a capsule of boiled salt solution (ʒj. to Oj.). But equally good results are obtained by using dead bone chips (either decalcified bone preserved in alcohol, or calcined bone) to fill up the space between the fragments.

Malunited fracture or vicious union.—1. Fractures in consequence of having been improperly set, or not kept at rest in good position, may unite at an angle (Fig. 101), or in some other faulty direction (Fig. 103). 2. If splints have been removed too early, or if in the case of the lower extremity the patient has been allowed to walk too soon, the callus may yield, and deformity result. 3. Two adjacent bones, as the radius and ulna in the forearm, may become united to each other by callus (Fig. 102). 4. A greenstick fracture from neglect to straighten the partially-bent bone before applying splints may consolidate in its distorted condition.

Treatment.—If the fracture is recent, and the fragments are not firmly united, the patient should be placed under an anæsthetic, the faulty position rectified with the hands, and splints properly applied. If fairly firm union has already occurred an attempt should still be made to re-fracture the bone, under an anæsthetic, with the hands; if this fails, and in long-standing cases, osteoclasia by means of Thomas's instrument should be undertaken, or subcutaneous or open osteotomy may be performed, or in some instances a wedge-shaped piece of bone or mass of callus removed. Some surgeons object to the osteoclast in that they affirm that it is difficult to gauge the amount of injury inflicted on the soft parts. If properly used, however, very little damage is done. From personal experience, Walsham can strongly recommend its employment. It should, of course, not be used indiscriminately, but restricted to suitable cases, such as angular deformity of the bones of the leg, as shown in Fig. 101, certain forms of malunited Pott's fracture, and some varieties of fracture of the forearm where the radius and ulna are not welded together by callus. In several cases of badly-set Pott's fractures Walsham has of late years divided the fibula subcutaneously and removed a wedge-shaped piece of bone from the internal malleolus with the most excellent

results. A sharp fragment projecting beneath the skin may sometimes be sawn off with advantage, though it should be remembered that such projections often become rounded off with time.

Separation of epiphyses.—An injury which in general results in fracture or dislocation, may in young people before the age of

Fig. 103.—Skiagram of a malunited fracture of the tibia and fibula. (Taken by Dr. Hugh Walsham.)

twenty-one, at which period the epiphyses have mostly united, cause a separation at the line of junction *between the diaphysis and the epiphysial cartilage.* A separation running between the epiphysis and the epiphysial cartilage is of very rare occurrence. *Pathological* separation following disease is considered under *Diseases of Bone.*

Traumatic separation of an epiphysis requires relatively great violence, and does not as a rule occur in slight injuries. Direct violence as when a limb is run over, or indirect violence as the entanglement

of the arm or leg in machinery or in spokes of a carriage-wheel so that the limb is violently wrenched, are characteristic causes. Muscular violence is rarely sufficient, although occasional cases are seen. Such accidents are most commonly met with in boys between twelve and twenty, girls being much less exposed to them, especially after fourteen years of age. The accident may happen during birth from excessive traction on the arm or leg, also in children from traction combined with twisting of the limb. But experiments on the cadaver at these ages show how much force has to be used. Intra-uterine separations and separations in young children from slight violence are really pathological in origin, due to some bone disease. In rickets the epiphyses are, if anything, more firmly attached to the diaphysis than normal. Force, when applied, is then mainly expended on the spongy, incompletely-ossified bone near the end of the diaphysis, which consequently bends. A sprain attended by pain may be followed by inflammatory softening and bending at this level.

A separated epiphysis if not displaced, or after complete reduction, readily unites, as quickly or more quickly than a fracture in the corresponding bone. But the union may be followed by diminished or arrested growth, either equally along the whole line so that the limb is shortened but straight, or unequally owing to the epiphysial line on one side being more damaged than on the other so that the limb is not only shortened but also deformed. Complications result from the severity of the violence. Periosteum is stripped up from the end of the diaphysis and much blood is extravasated beneath, in which suppuration is very liable to occur, whether the septic germs enter through a wound or some superficial lesion, or whether the infection is intravascular in origin as in the case of acute septic osteomyelitis. The [illegible] may [illegible] except when the epiphysis is intra-articular, [illegible] for the epiphysis itself appears to be relatively more resistant than is the end of the bone after epiphysis [illegible] so that I-shaped fractures into the joint are not met with but the end of the diaphysis may be fractured [illegible]

The commonest and most important seat of this injury is the lower end of the femur, next the upper end of the radius and then the upper end of the humerus. Others are less common and many are exceedingly rare. The separation of some of the smaller epiphyses are rarely important except from the occasional danger of suppuration leading thereby to [illegible] as the happens, for instance, after separation of the epiphysis of the great trochanter, described by Sir Astley Cooper.

Owing to the nearness of the joint and the great swelling due to blood extravasation which rapidly ensues, diagnosis was formerly difficult but separation of an epiphysis was more to be suspected of fracture than fracture dislocation. In traumatic

hæmarthrosis. The *x* rays, combined with examination and reduction under an anæsthetic, are the means now available for the proper diagnosis and treatment of these injuries. But the difficulties in the reduction of the displaced epiphyses, even under anæsthesia, owing to the intervention of torn periosteum, muscle or bone fragments, may be insurmountable except by an open operation.

See further, *Injuries of the Upper and Lower Extremity.*

A compound or open fracture is one in which there is a wound through the skin and other soft tissues leading to the fracture.

Cause.—The wound may be produced :—1. *At the same time as the fracture*, either by the violence directly tearing open the soft tissues, or, as is more usually the case, by one of the fragments being forced through the skin either by the original violence or by muscular contraction. 2. *Subsequently to the fracture*, by the patient trying to rise or to use the injured limb ; or by want of care in removing the clothes, in handling the fracture, or trying for crepitus. 3. *Still later*, by ulceration or sloughing of the skin, due to inflammation set up through failure to render and keep the wound aseptic, or the laceration of the tissues or the pressure of a projecting fragment or of the splint.

State of the parts.—There may be a mere puncture, with but little if any more injury to the soft tissues than may be met with in simple fracture ; or with or without a large external wound of the skin there may be extensive laceration of the soft tissues, protrusion of one or other fragment, extensive comminution of the bone, implication of a large joint, rupture of the main artery, vein, or nerve, and in extreme cases, crushing and laceration of the whole of the injured part of the limb.

Union of compound fracture.—When the wound is small, and has been closed at once, and the soft parts are but little injured, and septic or other bacterial processes are absent, repair is as a rule similar to that of a simple fracture. When the wound is large, or is septic, or there is much laceration of the soft tissues or comminution of the bone, extensive suppuration is very likely to ensue, and union is only effected when granulations spring from the ends of the fragments and the periosteum, the process being analogous to union of the soft parts by the second intention. The granulations form bone after the method known as "ossification in membrane." The loose fragments and injured tissues, where the bone is comminuted and the soft parts are much bruised or lacerated, are cast off by the process of sloughing and ulceration (Fig. 104), before healing ensues. Where, however, a fragment retains its connection with the periosteum, it may not lose its vitality, but may help in the restoration of the bone. Where a large portion of bone is denuded of periosteum it generally dies, and is usually separated as in the ordinary process of necrosis (Fig. 104). It may, however,

become embedded in the new bone, and remain a source of irritation for years.

Dangers of compound fracture.—1. *Immediate dangers:* shock and collapse from loss of blood, which may prove fatal in a few hours; more rarely fat-embolism. 2. *Intermediate dangers:* septic inflammation, attended by sloughing of soft tissues, necrosis of bone, septic osteomyelitis, or even gangrene of the limb, all of which may be followed by septicæmia or pyæmia, are the chief, but erysipelas and tetanus are also to be apprehended. 3. *Late dangers:* hectic fever, lardaceous disease, and exhaustion from long-continued suppuration.

The treatment varies according to the state of the parts, the age and health of the patient, and the situation of the fracture. Our aim, when this can safely be attained, should be to convert a compound into a simple fracture. Thus, when the wound is small—a mere puncture, and there is but little laceration of the soft tissues—it should, after being rendered thoroughly aseptic, be closed by an antiseptic gauze dressing, and the case treated as a simple fracture. Any fragment of bone that may protrude should be replaced after thorough cleansing of the skin (see p. 181), and slightly enlarging the wound if necessary, or be cut away. Where, however, although the external wound is small, there is extensive laceration of the soft parts or comminution of the bones, and it is probable from the dirty condition of the patient's skin that septic matter has gained admission, the skin is cleaned, the wound enlarged, pockets slit up, and thoroughly washed out with carbolic lotion (1 in 20), and any dirt ground into the bone scrubbed away with a brush if it cannot be otherwise removed. A drain-tube or plug of gauze may then be inserted, and the rest of the wound closed. When the wound is large and lacerated, or other serious injury of the bone, muscles, vessels, nerves, or neighbouring joint has been sustained, the question of amputation will arise. (See below, *Amputation in Compound Fracture.*) Having, however, determined to try to save the limb, the indications are—(1) to render the wound aseptic, and (2) to reduce the fracture and maintain the fragments at perfect rest. When this has been done and all hæmorrhage stopped, the fracture should be set as described under *Simple Fracture* (p. 243). If a fragment protrude it should, after thorough cleansing, be reduced where practicable, sawn off where not, care being taken not to remove more bone than is sufficient to accomplish the object. Splinters when attached by

FIG. 104.—Diagram showing process of separation of necrosed bone in compound fracture. A. Ensheathing callus; B. Internal callus; C. Necrosed fragments; D. Granulations lining wound leading to fracture. (After Billroth.)

periosteum should not be removed, but simply placed in position and there secured, under some circumstances by sutures. If it is found difficult to keep the fragments in place, they may be fixed in position by wiring, screwing, or pegging, in the way described above. The soft tissues, muscles, tendons, and fasciæ may now, under some circumstances, be united by sutures and the wound closed, except at the insertion of a drain-tube; but when there is much laceration, and thorough asepsis cannot be assured, the wound should be kept freely drained to prevent the decomposition of any extravasated blood and discharges by a large drain-tube or a plug of antiseptic gauze, or by making, if it seems necessary, a counter-opening. The limb should then be secured in some form of apparatus, so arranged that the wound is not covered by it, but is freely accessible for dressing without disturbing the fragments.

If the patient's general condition remains good, and he has no pain or discomfort, the dressings in an uncomplicated case may be left undisturbed till the wound has healed, or may be removed for the purpose of withdrawing the drain-tube or plug; but should suppuration occur, a careful inspection ought to be made daily to see that the drainage is efficient; and if any collection of pus, which is apt to form in the intermuscular planes, be discovered, it should be let out with antiseptic precautions and the wound irrigated frequently or continuously. Any portions of the bone that may necrose should be removed as soon as loose. When the wound has healed the fracture should be treated in the same way as a simple one. Any complications as erysipelas, etc., that may occur, must be controlled as described in other parts of the book. The *constitutional treatment* is the same as that indicated in other severe injuries. (See also *Simple Fracture.*)

Question of amputation in compound fracture.—In slight and uncomplicated cases, and, on the other hand, in those severe injuries in which the limb is completely shattered or pulped, or the injured part is merely attached by a few shreds of tendon or other soft tissue, the course to be pursued is quite clear—in the one case to spare the limb, and in the other to amputate immediately. But in other instances the question of attempting to save *versus* amputate becomes one of the most serious and anxious that the surgeon has to decide. It was formerly taught that we should amputate—1. If there is great laceration of the soft parts and extensive loss of skin. 2. If there is much comminution of the bone. 3. If the main artery or nerves of the limb are torn. 4. If a large joint is implicated. 5. If the limb is likely to be of little subsequent service from the severity of the injury; and 6. If the patient is old or his constitution broken down. No one of these signs is in itself a sufficient reason for amputating, and when we can succeed in rendering the wound completely aseptic, some of them, as comminution

of the bone, implication of a large joint, and the advanced age of the patient, can hardly be now ever considered as a justification for so severe a measure. The main considerations are: Can the wound be rendered aseptic, and, if so, is the arterial supply sufficient to prevent gangrene; is the condition of the nerves such that the limb will not be helplessly paralysed; and is the laceration of the muscles and tendons within such limits as will allow of a useful limb? If these questions can be answered in the affirmative an attempt should be made to save the limb; if in the negative, amputation should be done. The indications for amputation are more imperative if the fracture involves the lower extremity, as the femur, and especially the tarsus, since the feeble circulation through the foot renders gangrene very liable to occur should sepsis supervene, and sepsis is most difficult to prevent when the common tarsal synovial membrane is involved; but each case must be judged on its own merits, and some will attempt to so save what others condemn. Every legitimate effort should of course be made to save a limb, but we must remember that in attempting to do so we may place the patient's life in danger, and that too often it is a question of a limb *versus* the life.

The surgeons in former days found it necessary to do *primary* amputation because they could not check the septic processes which inevitably followed severe compound fractures. There is now no such necessity. As long as the bleeding is stopped and the limb treated antiseptically as above described, there is no need for haste. The onset of gangrene, sloughing, suppuration involving joints, or septicæmia, are indications, if at all extensive, for the so-called *intermediate* amputation, *i.e.*, within a day or two of the injury. The patient's condition is then more favourable, as he has recovered largely from the shock of the accident. *Secondary* or late amputation is required for septic osteomyelitis and necrosis, exhaustion, hectic, and amyloid disease.

Complication of a fracture.—(*a*) *Simple fracture* may be complicated by—(1) local concomitant conditions, as dislocation, extravasation of blood, rupture of the main artery, vein, or nerve, implication of a joint; (2) circulatory complications, venous thrombosis, embolism, fat-embolism; (3) nervous complications, shock, retention of urine, traumatic delirium; (4) later complications, gangrene from tight bandaging, crutch-paralysis, or involvement of a nerve in callus; (5) late septic complications, bedsores, sloughing over the fracture, followed by erysipelas, tetanus, etc.

(*b*) A *compound fracture* may in consequence of the open wound becoming septic be complicated, in addition to the above-mentioned affections, by any of the following, viz., *suppuration*, *sloughing*, *osteomyelitis*, *necrosis*, *acute arthritis*, *septic intoxication*, *septicæmia*, *pyæmia*, *hectic fever*, and *tetanus*.

Of these complications of fracture, whether simple or compound,

the only ones that need be further mentioned here are the following :—

Fracture combined with dislocation.—In *simple fracture* the treatment consists in placing, where possible, the fracture in splints, and then attempting the reduction of the dislocation ; or the surgeon may try to manipulate the dislocated portion into its socket, and then apply splints to the fracture. Where the dislocated end cannot be replaced it should be reduced at once by an open incision, especially in the case of the shoulder and elbow, and the fragments wired together. In *compound fracture* this complication is much more serious, especially when it occurs in the lower extremity and involves one of the larger joints as the knee or hip. If possible the treatment should be that just mentioned for simple fracture with dislocation, viz., reduction and fixation of the fragments. If comminuted, the fragments should be replaced or removed. Amputation is indicated only if the main vessels are ruptured or septic inflammation has already supervened, or cannot be prevented. In the smaller joints the dislocation may be reduced, and the case treated as a wounded joint complicated by fracture.

Fracture implicating a joint.—A *simple fracture* extending into a joint is not an uncommon accident ; indeed, the elbow and knee joints are always involved in fracture of the olecranon and patella respectively, and the shoulder and hip joints in the intra-capsular fracture of the neck of the humerus and femur. The injured joint if kept fixed, will become stiff or ankylosed, whilst the muscles moving it will waste. The treatment primarily indicated is that best suited to restore the utility of the limb. In the case of the hip joint fixation in extension obtains ankylosis and enables the limb to bear weight. On the other hand an injured shoulder must be moved freely from the first, regardless of the question of union, or excision will have to be done later to regain mobility. Fractures of the patella or olecranon must be united by wire, or if this procedure is contra-indicated, free movement must be carried out from the first, in order to retain mobility of the joint and muscular power in the quadriceps and triceps respectively ; a strong band of fibrous tissue then unites the fragments. See further under *Special Fractures.* A *compound fracture* extending into a joint, though more serious, does not necessarily call for amputation or excision, and may be treated in the way described under *Wounds of Joints*, as well as on the lines indicated above.

Fat-embolism is a rare complication of fracture, but is more frequent in the compound than in the simple variety and in bones that have undergone atrophy. It appears that in consequence of the crushing of the medulla, fat-globules gain admission into the veins and become lodged in the capillaries of the lungs, instead of, as in the usual course of events, being drained off by the kidneys. Such fat-globules are found in the urine and in the lungs and

kidneys after death by means of osmic acid. The condition is attended by dyspnœa, either cyanosis or pallor, collapse, irregular action of the heart, and at times by coma and death. Venesection, injection of strychnine, venous saline infusion, and artificial respiration should be tried in the way of treatment.

Crutch-palsy is due to the pressure of a crutch on the musculo-spiral nerve. It is best avoided by well padding the crutches, or by having handles to the crutches, so that part of the weight falls on the hands. The paralysis, which chiefly affects the extensor muscles of the forearm, giving rise to *dropped wrist* (p. 286, Fig. 109 A), usually passes off when the crutch is no longer used. Should it not do so, electricity and massage may be employed.

Paralysis or *neuralgia* sometimes occurs in consequence of the implication of a nerve in the callus. This condition is perhaps most common in fractures of the shaft of the humerus, the musculo-spiral nerve being involved in the callus as it lies in its groove. The result is dropped hand from paralysis of the extensors of the wrist and loss or impairment of sensation or pain, and trophic changes in the region supplied by the radial branch. An operation is then at times necessary to liberate the nerve.

Gangrene from tight bandaging is occasionally met with, and is of the moist variety. All bandages should of course be at once removed in the hope that the limb may recover. When the gangrene is thoroughly established, amputation above the seat of fracture, and well beyond the gangrene, must be performed. Short of gangrene, the partial cutting off of the blood-supply (*ischæmia*) may cause interstitial inflammation and degeneration of the muscles, followed by stubborn contracture.

Extravasation of blood into the tissues is not uncommon in simple fracture, owing to the tearing of some of the smaller blood-vessels by one of the rough fragments. The extravasated blood causes in some instances considerable swelling, and on making its way to the surface gives the part a bruised and black appearance, and frequently causes the cuticle over it to be raised into blebs. These blebs differ from those formed in gangrene in that they are fixed and firm, whilst the latter are moveable over the moist and slippery dermis beneath. The blebs should be snipped, opened, and iodoform dusted in. In rare instances suppuration ensues.

Rupture of the main artery or vein occasionally occurs, causing when the skin is unbroken a tense swelling at the seat of fracture, attended in the case of the artery with coldness of the limb and cessation of the pulse in the arteries below. Should the vein as well as the artery be ruptured or become compressed by the extravasated blood, moist gangrene is liable to ensue. In compound fracture rupture of the artery is, as a rule, easily diagnosed, in that pressure on the artery above the fracture stops the bleeding. *Treatment.*—Should the swelling in simple

fracture increase in spite of elevation of the limb, cold, and pressure on the main artery above, and gangrene threaten, three courses are open: 1, ligature of the artery above; 2, tying the artery at the seat of fracture; or, 3, amputation. In either limb amputation is required if gangrene has already set in, but under favourable conditions, and especially in the upper limb, ligature of the artery at the seat of fracture, with clearing out of clots and fixation of the fragments, should certainly be first attempted. But the conditions that call for the adoption of one or other of these methods are too various to discuss here. In compound fracture the vessel should be tied in the wound if possible.

INJURIES OF JOINTS.

Contusions of joints may be produced by any mechanical violence. They are generally attended with pain and stiffness on movement, and in severe cases with swelling from effusion of blood (*hæmarthrosis*), and, later, of serous fluid (*synovitis*) into the synovial cavity. If the contusion is neglected, especially in tuberculous children, acute or chronic inflammatory changes may ensue, leading to destruction of the joint. *The treatment* consists in placing the part in a plaster-of-Paris bandage, or when already swollen, at rest on a splint, and applying cold by means of an ice-bag or Leiter's tubes. Where there is much effusion into the synovial cavity, and consequently considerable tension and pain, aspiration of the joint may be advantageously practised, and pressure afterwards applied.

Sprains.—A sprain is a stretching or partial rupture of the ligaments of a joint with only momentary separation of the articular surfaces. Sprains are generally due to a violent wrench or twist of the joint, and are often accompanied by laceration of the tendon sheaths and of the soft tissues around. They are of most frequent occurrence in the ankle, shoulder, wrist, and knee.

Signs and diagnosis.—Severe pain, often localised to certain points, and increased on movement; inability to bear weight on the limb; swelling and ecchymosis from effusion of blood into and around the joint; and, later, inflammatory effusion. The absence of signs of fracture or of dislocation will usually suffice to distinguish a sprain from one or other of these injuries; but where there is much swelling it may be difficult or impossible to make a diagnosis till the swelling has subsided. If there is any doubt the injury should be treated as a fracture, or, better, the question of fracture or dislocation settled by the *x* rays.

The consequences of a neglected sprain may be very serious, especially in rheumatic and gouty subjects. Thus, as the result of the incomplete absorption of the inflammatory products, the imperfect

repair of the torn ligaments, the formation of fibrous adhesions in and around the joint, and the gluing of the surrounding tendons to their sheaths, a sprain may be followed by long-continued pain, stiffness, weakness, and even fibrous ankylosis of the joint. At times in the tuberculous a sprain may be the starting-point of tuberculous arthritis, and in the rheumatic of rheumatic arthritis.

Treatment.—The indications are to stop further effusion of blood and relieve the pain by placing the joint at perfect rest for a few days, with the torn ligaments relaxed; to prevent inflammation and promote the absorption of the effused blood and inflammatory products, and so prevent stiffness or ankylosis, or if these have ensued to restore the mobility of the joint by breaking down any adhesions that may have formed. Thus, if seen at once, a plaster-of-Paris or a Martin's bandage should be put on over wool; or if much swelling has already occurred, the parts should be placed on a splint, or in a sling, and, either cold, in the form of lead-lotion or ice, or heat, in the form of hot fomentations, applied. For very slight cases, however, a few days' rest, with the part supported by a wet bandage, followed by the use of a stimulating liniment, is all that is usually necessary. The joint in any case should not be kept for long at rest lest stiffness ensue; but as soon as the patient can bear it massage and passive movements should at once be begun. If stiffness or fibrous ankylosis has already occurred, friction, shampooing, and massage may still be tried; or the joint may be first of all forcibly moved under an anæsthetic.

Dislocations.—A dislocation is the forcible displacement of the articular end of a bone from the part with which it is naturally in contact.

Varieties.—Dislocations may be divided into the traumatic and the pathological; the latter, including the congenital, are treated of elsewhere (see *Diseases of Joints*).

Traumatic or accidental dislocations are spoken of as *compound* or *simple* according as they are, or are not, complicated with an external wound leading into the joint; and in either case as *complete* or *partial* according as the articular surfaces are, or are not, completely separated from each other.

The causes of dislocation are predisposing and exciting. *The predisposing causes* may be enumerated as:—1, weakness of the ligaments surrounding the joint from previous dislocation or disease; 2, the shape of the joint—ball-and-socket joints from their extensive range of movement being more easily dislocated than hinge joints; 3, middle life—the bones being then strong and capable of resisting fracture and the muscles powerful; the kind of violence likely to produce a dislocation in adults is in children more likely to cause separation of an epiphysis, and in the old and feeble a fracture; 4, the male sex—men being more continually exposed to violence than women. *The exciting causes* are usually, 1, external violence, either

direct or much more often indirect, and sometimes, 2, muscular action. Examples of each will be met with in the section on special dislocations.

The signs common to all dislocation are: 1. Alteration in the shape of the joint. 2. Inability to move the limb on the part of the patient, and more or less fixity to the efforts of the surgeon. 3. An alteration in the relations of points of bone about the joint. 4. An abnormal position of the end of the displaced bone; and 5. Shortening or apparent lengthening of the limb, or an alteration in its axis. The signs are frequently obscured by swelling in and about the joint, due to extravasation of blood or effusion of synovial fluid, and the pain is often so intense, especially on manipulation, that the patient will not allow a thorough examination to be made. Hence in all doubtful cases the position of the bone should be ascertained by means of the *x* rays, or if this is not practicable by an examination under an anæsthetic.

Where the dislocation, as is so often the case, is complicated with a fracture, the preternatural immobility, so characteristic of a dislocation, may be no longer present, since there may be some movement at the seat of fracture. In such a case crepitus being obtained, the injury may be ascribed entirely to the fracture, and the dislocation be overlooked; hence the greater importance in all doubtful cases of examination by the *x* rays and under an anæsthetic.

The state of the parts will be more particularly referred to under each special dislocation. Here it may be briefly stated that the articular end of the bone is generally forced through the capsular ligament; whilst other of the ligaments, surrounding tendons, and muscles may be lacerated, ruptured, or tightly stretched, and the arteries and nerves displaced, pressed upon, or torn. In the ball-and-socket joints the head of the bone will be found either opposite the rent in the capsule or drawn to some distance from it by muscular contraction. If reduction is affected early, the damaged ligaments and muscles are soon repaired; but they remain for some time weakened and stretched, and thus predispose to re-dislocation. Hence the importance of keeping the parts at rest until firm union of the ruptured capsular and other ligaments has occurred. After reduction a moderate amount of inflammation and serous effusion in and about the joint generally ensues, but usually subsides in a few days if the parts are kept at rest, the joint becoming gradually restored to its normal condition. If rest is neglected, however, the rent in the capsule may not heal, but remain as a permanent hole with smooth edges, allowing the head of the bone to slip in and out of its socket. In some instances, moreover, the inflammation may run into suppuration, which may be followed by ankylosis of the joint.

The impediments to reduction are:—In *recent cases*:—1. The spasmodic contraction of the muscles surrounding the joint. 2. The small size of the rent in the capsule. 3. The hitching of points of

bone on each other; and 4. The interposition of ligaments, tendons or muscles. In *old-standing cases*:—1. The formation of adhesions around the displaced bone. 2. The closure of the rent in the capsule. 3. The permanent shortening of the ligaments and muscles; and 4. The alteration in the shape of the articular surfaces, in part from absorption or filling of a cavity by fibrous tissue, and in part from the formation of new bone. The contraction of the muscles generally increases from the time of the accident; hence every hour a dislocation remains unreduced the more difficult the reduction becomes.

The consequences of non-reduction are either the formation of a new joint or ankylosis, the former being more common in ball-and-socket joints, the latter in hinge joints. When any movement between the dislocated bones exists, the osseous surface on which the displaced bone rests is converted into a new articular cavity by a process of absorption of the old bone and the formation of new bone around. The end of the displaced bone becomes adapted by a similar process of absorption to its new socket, the articular cartilages being eroded, and the exposed surface eburnated and polished; the soft tissues around become condensed so as to form a kind of new capsule. The old socket in the meantime becomes more or less obliterated, its articular cartilage absorbed, and its cavity filled up with fibrous tissue or new bone, changes which give the joint very much the appearances seen in osteo-arthritis. The range of movement in the newly-formed joint will at first be limited, owing to the muscles undergoing adaptive shortening and the torn tendons forming new attachments, but in the course of time, under appropriate treatment, will become much more free, and a very fairly useful limb may be obtained. When, on the other hand, the dislocated bone is immoveably fixed upon another the articular cartilage is absorbed, the continuous osseous surfaces unite, and bony ankylosis ensues. The muscles, moreover, from want of use, undergo shortening or partial atrophy and fatty degeneration, leaving the limb in a more or less shrunken and wasted condition.

Treatment.—The indications are:—1. To replace the articular surfaces in contact; and 2. To keep them there until the rent in the capsule has united and the torn ligaments and muscles have had time to heal. Unless the case is seen immediately after the accident, whilst the patient is faint and the muscles are in consequence relaxed, an anæsthetic had better be given to overcome the resistance of the muscles. The reduction may then be effected either by, 1, *manipulation*, or, 2, *extension*.

1. *Manipulation* consists in putting the limb through certain movements of flexion, extension, rotation, and circumduction, varying according to the situation and variety of the dislocation. By means of these movements we endeavour:—(*a*) To overcome the obstacles to reduction by relaxing the stretched ligaments and tendons and disengaging any hitching points of bone; and (*b*) To

make the displaced head retrace as it were its steps and re-enter its socket. In order to employ manipulation successfully it is essential that the surgeon should know the anatomy of the part, the direction in which the bone has travelled to reach its abnormal situation, and the probable position of the rent in the capsule.

2. *Extension* is a much less scientific method of reducing a dislocation, and should never be resorted to except in certain forms of dislocation, which will be mentioned hereafter, till manipulation has been tried. It was the method almost always employed by the older surgeons, and has for its object the forcible dragging of the displaced end of the bone into its socket, or opposite its socket, into which it is then drawn by muscular contraction. In many forms of dislocation the method is as harmful in practice as it is wrong in principle, since the displaced head, as in some forms of dislocation of the hip, can only be drawn into its socket in this forcible manner by rupturing the resisting ligaments and tendons. In employing extension, traction is made in the long axis of the limb by the surgeon, either with his hands or by means of a jack-towel secured by a clove hitch to the limb, or if more force is required by multiplying pulleys. Counter-extension is in the meanwhile made in the opposite direction to the extending force, but in the same straight line, either by the surgeon pressing with his heel or knee on the part above the dislocation, or by fixing the part with a jack-towel or suitable strap to a hook in the floor or wall. When sufficient extension has been employed to draw the head of the bone opposite its socket the surgeon should endeavour to guide it into its place. Before the introduction of chloroform this was usually effected by the contraction of the muscles themselves after the head had been drawn down by the extending force.

In old-standing cases, before either manipulation or extension is employed, the adhesions, which offer the chief obstacle to reduction, should be first broken down by cautiously rotating or circumducting the limb. When the rent in the capsule has united, the old socket been filled up, and a new joint formed, reduction is, of course, physically impossible; but even then the breaking down of the adhesions may greatly improve the range of motion and consequent usefulness of the limb. In attempting the reduction of a long-standing dislocation, however, great care must be exercised, or irreparable damage may be done. Rather than use any great violence it is in some cases better at once to cut down upon the dislocation and divide any fibrous bands that may be found preventing reduction. Not only may the accidents below enumerated be thus avoided, but reduction may be safely accomplished at later periods than was formerly possible; and with antiseptic treatment of the wound there is but little risk, and good movement of the joint may be expected. If after the division of the adhesions the reduction cannot be effected, the joint should be excised.

Among *the accidents that have attended violent efforts at reduction* may be mentioned:—1. Rupture of the main artery, vein, or nerves. 2. Laceration of muscles and tendons. 3. Tearing open the skin and soft tissues, thus rendering the dislocation compound. 4. Fracture of the bone. 5. Inflammation and suppuration of the joint and surrounding parts; and 6. The avulsion of the limb.

How long after a dislocation may an attempt be made at reduction?—Sir Astley Cooper gave the time at between three and four months; but since the introduction of chloroform successful cases have been reported after much longer periods. In an old-standing case the circumstances that should influence us in deciding whether an attempt at reduction should be made, are the age of the patient, the situation of the dislocation, the presence or absence of pain, and the amount of usefulness of the limb. By the open methods, the time at which a dislocation can be reduced is considerably extended. They, however, should not be employed unless the movements of the joint are much restricted and the usefulness of the limb is in consequence greatly impaired, and unless severe and continued pain is elicited by movements of the joint, since by perseverance with massage and passive movements a quite useful limb, even in cases which at first appear to be very unpromising, is often obtained.

The *after-treatment* in an ordinary case consists in maintaining the part at rest by suitably applied strapping and bandages, and in preventing or subduing inflammation by cold, evaporating lotions, etc. The part, however, should not be kept at absolute rest longer than is sufficient for the torn ligaments and other soft tissues to heal, lest adhesions form and stiffness of the joint ensue. Passive movements, therefore, should be cautiously begun after a few days; and friction, shampooing, or galvanism subsequently employed to restore the tone of the wasted muscles. Where stiffness has occurred the adhesions should be broken down under an anæsthetic, provided there are no signs of active inflammation in the joint.

Treatment of compound dislocations.—The dislocation should be reduced, the parts placed at perfect rest, and the case treated as a wound of the joint (see *Wounds of Joints*). In consequence of the extensive laceration of the ligaments and other soft tissues reduction is usually quite easy. When a compound dislocation is combined with a fracture of the bone, and there is much laceration of the soft parts, amputation of the limb in the lower extremity, and resection of the joint in the upper, will probably be required.

Congenital dislocations, so-called, generally depend upon some malformation of the articular surfaces rather than upon actual intra-uterine displacement of an originally normal articulation. True dislocations do sometimes occur during birth. The malformations are all rare, with the exception of the so-called "congenital dislocation" of the hip (*q.v.*).

Wounds of joints.—A joint may be merely punctured, or it

may be laid freely open. The wound may be of an incised, lacerated, or contused character, and complicated by extensive injury of the surrounding soft tissues, or by dislocation or fracture of the articular ends of the bones. In the latter case the wound may be further complicated by the protrusion of the dislocated bones or the ends of the fragments.

A wound of a large joint should always be regarded as serious, as owing to the difficulty of securing an efficient drain, and of preventing decomposition of the extravasated blood and serous secretion in the synovial pouches, septic inflammation is very liable to be set up, followed by suppuration and disorganisation of the joint. The peculiar absorptive power of the synovial membrane, moreover, favours the entrance of the chemical products of decomposition into the system, and consequently enhances the risk of septic intoxication, to which, or to septicæmia or pyæmia, the patient may succumb. Further, should he survive these earlier dangers of blood-poisoning, he is still liable to fall a victim to hectic, or to exhaustion or lardaceous disease consequent upon the prolonged drain on the system attending the suppuration in the synovial membrane, the articular ends of the bones and the surrounding soft parts.

Medium-sized wounds are the most dangerous, as such cannot always be rendered aseptic nor drainage be effectually secured. Punctured wounds, when made with a clean instrument and in an oblique direction, may heal under appropriate treatment without any inflammatory or other trouble. Should septic germs, however, gain admission at the time of puncture, or subsequently through neglect of the wound, or should the joint not be kept properly at rest, a punctured wound may be followed by the most intense inflammation of the synovial membrane and total disorganisation of the joint with its attendant dangers of blood-poisoning. Extensive and lacerated wounds of joints, when not sufficiently severe to call for amputation or excision, are not necessarily a source of extreme anxiety, as they usually permit of effectual cleansing and drainage, and under the use of antiseptics may heal up by granulations without giving rise to any serious constitutional disturbance. In such cases, however, bony ankylosis will generally ensue, though in some instances the cartilages may escape destruction, and a fairly moveable and useful joint may be obtained.

Signs.—When the joint is laid freely open the nature of the injury is obvious, and any displacement or splintering of the bones can be seen or ascertained by examination with the finger. When the wound is of a punctured character and the incision in the skin is some distance from the joint the signs are not always so apparent. In such cases an account of the depth to which the instrument penetrated, and of the direction in which it appeared to run, will help us to determine whether the synovial membrane has been entered. The escape of a glairy fluid like the white of egg—

the synovial secretion—will make the diagnosis certain. If in doubt, the case should be treated as if the joint had been opened, but on no account should the wound be probed for the purpose of settling the point, since septic matter might be introduced from without, and a wound that did not in the first instance penetrate the cavity might be made to do so. Should inflammation ensue the signs will be the same as those of acute arthritis (see *Diseases of Joints*).

The *treatment* will depend on the size and character of the wound, the joint affected, the nature of the complications, and the age and constitution of the patient. The chief indications are to prevent septic inflammation and its attendant consequences, or if the injury is of a very severe character, to endeavour to save the patient's life by the sacrifice of his limb.

1. *Treatment of small or punctured wounds.*—(*a*) If the wound has been inflicted by a presumably *aseptic* instrument, an attempt should be made to convert it into a subcutaneous wound by sealing it with iodoformised collodion, or, better, by placing over it an antiseptic dressing, after having first thoroughly cleansed the skin around and rendered it aseptic. One or more fine silkworm-gut sutures may first be inserted if the wound is too large to be closed in this way. The limb should be then placed on a splint at perfect rest, and cold applied by means of an ice-bag or by Leiter's tubes. Should acute inflammation follow, half-a-dozen leeches may be placed over the joint, and warm applications substituted for the cold; whilst should the local and constitutional disturbance increase and the joint become distended, aspiration should be practised to relieve tension and to examine the exudation, opium given to soothe the pain, and the treatment persevered in. If, however, *pus* is withdrawn by the aspirator, the joint should be laid freely open, drained, dressed antiseptically, and placed in the position in which, should ankylosis ensue, it will subsequently be of most use. If, notwithstanding free incisions, the suppuration goes on, continuous irrigation with some antiseptic fluid may be tried, or the whole limb kept continuously in a hot bath, the patient, if necessary, as in the case of the knee, being himself immersed. Or after scrubbing and even scraping out the whole of the joint, through a free incision, the whole cavity may be packed with iodoform gauze for a day or two, the joint meanwhile being in a relaxed position. As soon as the synovial surface looks healthy and vascular, the joint is sewn up except for a small drain. Should signs of septic exhaustion with hectic set in, amputation must be performed. (*b*) If the instrument with which the wound has been inflicted is undoubtedly *septic* or there is any doubt on this point, the wound, after cleansing the skin, should be opened up to ascertain if the joint has been penetrated. If this is found to be the case, the joint must then be freely opened, rendered aseptic if possible, and drained.

2. *Treatment of large and complicated wounds.*—The joint should be thoroughly cleansed with antiseptic lotions, well drained, and dressed antiseptically. A counter-opening at a dependent spot may in some cases be advantageously made, as for instance in the popliteal space in wounds of the knee, and a tube passed through the joint. Where there is extensive laceration of the soft parts and much comminution of the bones, such as may be produced by a bullet or railway smash, and it is next to certain that septic material has been introduced as when pieces of clothing have been forced into the joint, or where there are other complications of such a nature as to render it doubtful whether a useful limb can be obtained, the question of excision or amputation must be raised. In deciding on the propriety of an operation the surgeon will be influenced by the situation of the joint, whether it is septic or not, and the probable power of the patient, either on account of his age or the general state of his constitution, to stand the acute inflammation and prolonged suppuration which may ensue if the limb is not removed. Briefly it may be said, that an injury which in the elbow might be treated by excision of the joint, would in the knee probably call for amputation; that a wound of the carpus or tarsus is generally more serious than one of the wrist or ankle; and that the sacrifice of the limb is required for a much less severe wound of the knee than of the ankle.

INJURIES OF MUSCLES AND TENDONS.

Contusions of muscles are very common as the result of falls, blows, kicks, or other violence. They may vary from a slight bruising with or without tearing of the muscle-fibres and blood-extravasation to complete pulping of the muscles. *Signs.*—In the slighter cases there is dull aching pain increased on movement, ill-defined and deep-seated swelling, and later, ecchymosis as the blood makes its way to the surface. Some stiffness or loss of power from partial atrophy frequently follows, and occasionally inflammation and abscess. Severe cases are frequently associated with other injuries of the part, as fracture of a bone, laceration of a large blood-vessel, etc. The *treatment* consists in keeping the part at rest with the muscle as much as possible relaxed, and in preventing inflammation by cold, lead and opium lotions, and the like. Shampooing, massage, and galvanism may subsequently be necessary to restore any loss of power that may ensue.

Wounds of muscles may be incised, lacerated, punctured, or contused. When the wound is made transversely, the divided ends, which gape widely, must be approximated by placing the limb in such a position as will relax the muscle, and then united by aseptic sutures. When the wound is deep or parallel to the fibres a drainage-tube may be inserted to prevent the retention of the

discharge by the bulging of the muscle. Union takes place by fibrous tissue.

Rupture of muscle may occur from a sudden and violent spasmodic action, or during vomiting, tetanus, or delirium. As examples may be mentioned rupture of the sterno-mastoid of the child in a difficult birth, the rectus abdominis in parturition, the biceps in raising weights, the supinator longus and gastrocnemius in lawn-tennis the quadriceps extensor at football, and the adductors of the thigh in riding. A sensation of tearing is often felt at the moment of rupture, followed by pain and, if the rupture is complete, by loss of function. The rupture is indicated by a gap, above or above and below which a rounded, smooth, soft or semi-fluctuating swelling formed by the ends of the retracted muscle is felt to bulge up when the muscle is put into action. On carrying the palm of the hand along the muscle the swelling disappears, and the hand sinks into the gap between the ruptured ends ; or blood is extravasated between the ruptured ends, often occasioning a large hæmatoma. Rupture of the sterno-mastoid in infancy is followed by contraction of the muscle and consequent wry-neck. The *treatment* consists in approximating the divided ends as much as possible by position and by suitable bandages and splints, and in applying ice and evaporating lotions to control the blood-extravasation and to prevent inflammation. The biceps or quadriceps may be exposed immediately and sutured with kangaroo-tail tendon. If a blood-tumour forms, it should not be opened unless suppuration occurs.

Rupture of a muscle sheath is not infrequently seen, as in the thigh in football players. The affected muscle, generally the rectus, bulges through the rent in the sheath, on being put into action, in the form of a soft rounded swelling or hernia. In cases where there is weakness the sheath may be sewn up with kangaroo-tail tendon.

Rupture of tendons.—A rupture of a tendon may occur as the result of external violence or during some sudden and involuntary muscular action, and is very common in the plantaris and tendo Achillis, and somewhat less so in the biceps (see *Injuries of the Upper and Lower Extremity*). The tendon, except when the ends become widely separated, as generally happens in the case of rupture of the long tendon of the biceps, usually unites readily on the ends being approximated and kept at rest in that position.

Wounds of tendons.—When a tendon is divided in an open wound its cut ends should be approximated by placing the parts on a splint in such a position that the muscle is as much as possible relaxed, and the divided ends then united by kangaroo-tail tendon sutures. In old-standing cases not united immediately, or where union has failed, or in cases of subcutaneous rupture leaving weakness, an attempt should be made to unite the cut tendon if the patient's general state of health is favourable. A careful dissection

is needed where there has been extensive destruction of the tendon or adhesion to the neighbouring structures. When the ends of the divided tendon are found to have retracted and to be so far apart that they cannot be made to meet, one end may be split longitudinally, but not quite to the divided end, turned down and united to the other end by suture; or the ends may be united by a tendon graft or leash of catgut, kangaroo-tail tendon or silk, which becomes surrounded by new tendon. In other cases, as in the tendons of the fingers, the distal end may be united laterally to a neighbouring tendon or inserted by splitting.

Dislocation of a tendon from its sheath or groove without fracture or other injury occasionally occurs from a sudden twist or strain. It is indicated by pain and partial or complete loss of function of the affected muscle, swelling and ecchymosis; whilst on examination the displaced tendon may sometimes be felt in its abnormal situation, or may be seen or felt, as in the case of the peroneus longus, to suddenly leave its groove and protrude in front of the malleolus during certain movements of the foot. The injury is most common about the ankle and wrist, back and neck. The *treatment* consists in replacing the tendon by manipulation, breaking down any adhesions that may have formed, and retaining it in place (which is often difficult) by a suitably applied pad and bandage, or in the case of the ankle or wrist by a plaster-of-Paris bandage, and subsequently by a leather support. In an obstinate case in which all mechanical measures had failed, Walsham succeeded in making a new sheath for the tendon by dissecting up a flap of periosteum from the fibula and sewing it over the tendon to the soft tissue at the back of its groove on the malleolus.

Evulsion or tearing out of a tendon with a part of its muscle occasionally occurs as the result of catching the finger or thumb in a machine, on a hook, etc. Part or the whole of a digit is usually torn off, bringing away with it the flexor tendon, this being more firmly attached to the bone than the extensor. In consequence of the tendon sheath being thus left open suppuration is liable to extend along it into the forearm. Free drainage of the wound and antiseptic dressings are then imperative.

INJURIES OF ARTERIES.

Contusion or bruising of an artery without laceration or other injury of its coats is of occasional occurrence, and is said to be followed by contraction and permanent diminution in the size of the vessel, and should the vessel be calcareous, by thrombosis and senile gangrene.

Rupture or subcutaneous laceration of an artery may occur as the result of any severe violence, but is perhaps most often due to the passage of a wheel over a limb, incautious attempts to reduce

an old dislocation of the shoulder, and excessive violence in breaking down adhesions in stiff joints.

1. *The rupture may be partial, i.e.*, the internal and middle coats only may be torn. In such a case the external coat may subsequently yield to the pressure of the blood, thus laying the foundation of an aneurysm; or the internal and middle coats may be folded inwards into the interior of the vessel, obliterating its calibre, and in this way may cause, especially if the vein is also injured, gangrene of the limb (Fig. 105).

2. *The rupture may be complete, i.e.*, all the coats may be torn across. Here in a similar manner the artery may become occluded without any hæmorrhage; or blood, often in enormous quantities, may be poured out into the tissues of the limb. In either case gangrene may ensue, especially if the vein is also ruptured and the injury occurs in the lower extremity; or the skin may finally give way from the pressure of the ever-increasing extravasation, and the patient die from a sudden gush of blood. In some instances suppuration may occur. Sometimes the extravasated blood, particularly in the upper extremity, may become encysted, a sac being formed for it by the inflammation and condensation of the surrounding tissues. This condition is called a *circumscribed* traumatic aneurysm in contradistinction to *diffused* traumatic aneurysm, the term sometimes applied to the injury when the blood is simply extravasated into the tissues, though in this latter case the name ruptured artery is more appropriate.

FIG. 105.—Obliteration of the subclavian artery by the infolding of the internal and middle coats without injury of the external coat.

The *symptoms* vary according to the nature of the injury. When the main artery becomes occluded there will be pain at the seat of rupture and cessation of the pulse below, while later gangrene will probably, though not invariably, ensue. Should the artery not be occluded, blood in large quantities will escape into the tissues, giving rise to a rapidly increasing swelling, in which no pulsation can, as a rule, be detected, although a bruit may sometimes be heard; the limb becomes cold, and livid, and swollen, and the pulse, as a rule, can no longer be felt in the arteries below. When the extravasation is very large, constitutional symptoms of hæmorrhage will also be present, and signs of gangrene, if the ruptured artery is in the lower limb, will probably soon supervene, since not only is the main arterial supply cut off, but the collateral flow and venous return are also impeded by the

pressure of the extravasated blood on the collateral arteries and veins. On the other hand, should the blood, as occasionally happens in the upper limb, become encysted, the swelling will slowly assume the characters of an ordinary aneurysm. At times suppuration occurs, and the swelling then presents all the characters of a huge abscess.

Treatment.—(*a*) *When the artery is occluded* all that can be done is to endeavour to prevent gangrene occurring by maintaining the warmth of the limb till the collateral circulation has had time to become established. Should gangrene occur amputation must be performed as soon as a line of demarcation has formed above the injury. (*b*) *When blood in large quantities is extravasated into the tissues* the treatment will depend on the situation of the ruptured artery. Thus, in the case of the popliteal, amputation has until recently been the rule of practice, especially if the vein has also been ruptured, as gangrene, for the reasons stated above, is very liable to ensue if the main artery is tied either above or at the seat of rupture. With strict antiseptic precautions, however, an attempt should be made to save the limb by cutting down at the seat of rupture as soon after the accident as possible, turning out all the clot, and tying the artery, and vein if also wounded, above and below. In the case of the axillary, where the collateral circulation is much more free, the ruptured artery may safely be cut down upon and secured above and below the bleeding spot. Should suppuration occur, a free incision should be made, the pus and breaking-down clots turned out, and any vessel seen bleeding tied. The wound should then be plugged with antiseptic gauze, a tourniquet lightly applied, and the patient watched for secondary hæmorrhage. If this threatens the artery should be tied in its continuity above. If hæmorrhage again occurs amputation is called for.

Wounds of arteries may be divided into the penetrating and the non-penetrating.

1. *The non-penetrating* are those in which either the outer coat only, or the outer and middle coats are notched or torn Here the wound may heal, or the uninjured coat or coats may ulcerate, or give way and hæmorrhage ensue, or may gradually yield, as may also the cicatrix left on the healing of the wound, to the pressure of the blood, and lead to the formation of an aneurysm.

2. *The penetrating* are those in which the interior of the artery is laid open. In this case much will depend upon the size of the artery, and whether it is completely or only partially cut across, and upon the direction and size of the wound.

(*a*) *Wounds of large arteries*, as the aorta or pulmonary artery, whatever their nature, are usually immediately fatal.

(*b*) *Wounds of arteries of the second and third degree*, as the femoral and brachial. If the artery is *completely divided*, and the edges of the wound are cleanly cut, repeated hæmorrhages rapidly

terminating in death will generally ensue; but if the edges are uneven and ragged, as in the avulsion of a limb by machinery or by a cannon ball, the external coat becomes twisted up, and the middle and internal coats retract and contract, a clot forms within the vessel, and no hæmorrhage occurs. If the artery is *partially divided* and the wound is made transversely to the long axis of the vessel, the longitudinal tension of the elastic coat causes the wound to gape and assume an oval or circular shape, according to the length of the incision, and severe hæmorrhage will ensue; but if the wound is made parallel to the long axis of the vessel, and is small (a mere puncture), it may heal by adhesive inflammation. In the latter instance the cicatrix may remain permanent, or it may subsequently yield, producing a traumatic aneurysm.

(*c*) *Wounds of medium-sized arteries*, as the radial and tibials, are attended, when the vessel is *completely and evenly divided*, by sharp hæmorrhage, followed by syncope, and temporary arrest from the formation of a clot. The artery may then become permanently occluded; usually, however, as the heart's power is restored the clot is washed away and hæmorrhage recurs. In this way hæmorrhages, alternating with temporary arrests, continue until death ensues from exhaustion. When the edges of the wound are *uneven*, or the artery is only *partially divided*, the effects are similar in each case to those described above in arteries of larger size.

(*d*) *Wounds of small arteries.*—If the artery is *completely divided*, it will usually become occluded in the way described under *Method of arrest of Hæmorrhage* (p. 209); but if only *partially divided* such occlusion does not, as a rule, take place, and repeated hæmorrhages follow. Complete division will then often suffice to cause its occlusion, a plan which was frequently resorted to when bleeding from the temporal was practised.

When the wound through the soft tissues leading to a wounded artery is small or of a punctured character, the superficial part of the wound may close, whilst the blood continues to be extravasated from the wounded vessel into the deeper part, where it may become encysted from the condensation of the soft tissues around (*circumscribed traumatic aneurysm*).

Treatment of wounded arteries.—1. When an artery is seen spouting in an open wound a ligature should at once be applied to the bleeding end. (See *Arrest of Hæmorrhage*, p. 211).

2. When the end of a large artery is seen pulsating, but not bleeding in consequence of it having been *torn* across, it should be exposed and ligatured, a precaution which would now be considered necessary.

3. When an artery is exposed for some distance in its continuity two ligatures had better, as a rule, be applied and the artery divided between them, especially if it be notched or bruised.

4. When an artery has ceased to bleed, even though the hæmorrhage may have been sharp, the wound should on no account be

enlarged for the purpose of tying the bleeding vessel, unless it can be seen or felt; since not only may it not bleed again, but as the bleeding has ceased it may also be difficult or impossible to find it. In such a case, however, especially if the patient is much collapsed, he should be watched for the first sign of any return of the hæmorrhage, firm pressure in the meantime being applied over the wound, and where practicable over the course of the main artery above and below. The whole limb, moreover, should be carefully bandaged from below upwards. This rule only applies to primary hæmorrhage. In secondary hæmorrhage, it is exactly the reverse; although the bleeding has ceased, the vessels must be sought and secured, as another and perhaps fatal hæmorrhage is almost sure to ensue.

FIG. 106.—Diagram to illustrate the manner in which, after a ligature has been applied at a distance from a wound in an artery, the blood may be carried back again into the artery above and below the wounded spot by collateral vessels. The arrows indicate the direction of the blood current.

5. When the hæmorrhage is moderate but clearly arterial, the external wound small, and the artery not seen, pressure should be applied in the way mentioned above, and will probably suffice.

6. When the bleeding is severe and evidently arterial, and the external wound is still open, whether the wound be deep, recent, inflamed, or sloughing, the well-established rule—to which, however, there are of course exceptions—is *to cut down upon the bleeding point and apply a ligature to each end of the artery if divided, or above and below the wound if the artery is punctured or only partially cut across.* To do this it is generally sufficient to enlarge the wound in the soft tissues; but where the wound is on one side of the limb and the bleeding apparently comes from an artery on the other, a probe should be passed through the wound, its projecting point cut down upon, and the bleeding artery sought through this incision and tied as above. The object of this procedure is to prevent the necessity of making a very large wound.

The reasons for tying an artery at the place where it is wounded are:—1. It is often impossible to determine, without cutting down upon it, what artery is bleeding, and should the alternative plan of securing the main artery higher up be adopted, the wrong artery after all may be tied, and the bleeding continue. Thus, for example, in a supposed wound of the femoral it might be the profunda, or even a small muscular branch, that was bleeding. 2. Even supposing the main trunk were the one wounded, the blood might still be carried

by the collateral vessels into the artery beyond the ligature either above or below the wound in the vessel, and bleeding recur from either the proximal or distal end respectively (Fig. 106). 3. Should, moreover, ligature of the main artery higher up thus fail to arrest the hæmorrhage, not only will the patient be further reduced by loss of blood, but the subsequent ligature, which will then probably in the end have to be applied to the bleeding artery in the wound, may through the extra interference with the collateral vessels induce gangrene of the limb. 4. Tying the main artery above is in itself in some cases, as the subclavian in wounds of the axillary, a more dangerous and difficult procedure than enlarging the wound.

The reason for applying a ligature to both ends of the vessel if it is divided, or above and below the wound if it is merely punctured or only partially cut across, is that ligature of the proximal end only may be insufficient to arrest the hæmorrhage, since the blood, as seen in Fig. 106, may be carried round by the collateral channels into the artery below the wound and may thence escape by the open distal end.

Recently several successful cases have been reported in which a wound in a *large artery*, axillary, femoral, has been *sutured*, the stitches being so passed as to bring the endothelial surfaces into contact.

In some instances the above rule of cutting down upon and tying the artery at the wounded spot cannot be carried out. Thus, where the artery is *inaccessible*, as in punctured wounds of the tonsil, or about the angle of the jaw where important structures would be damaged by enlarging the wound, it may be necessary to tie one of the carotids. Moreover, it may at times be safer to remove a limb than to search for the bleeding vessel, as for instance in suppurating and sloughing tissue and in wounds of the posterior tibial artery in the upper third of the leg, especially if the injury is complicated by fracture. Again, it may not only be found impracticable to ligature the artery at the wounded spot, but also impossible to tie or even compress the main vessel nearer the heart, as for instance in wounds of the subclavian above the clavicle. Here all that can probably be done is to apply pressure firmly by filling the wound with strips of gauze and covering with an elastic bandage, or keeping up manual pressure for some hours.

Whilst cutting down upon a bleeding artery hæmorrhage should be restrained by the use of an elastic tourniquet or the fingers applied to the main artery above the wound; and in the case of a wound of the carotid, subclavian, external iliac, or gluteal by compressing the artery above by a temporary ligature, or by a loop drawing up the artery against the finger, through a separate incision. Where it is impracticable to control the bleeding in any of these ways, the wound should be sufficiently enlarged to admit one or two fingers, and the bleeding vessel having been recognised by the escape of

warm blood, should then be compressed by the finger or sponge on a holder, the wound further enlarged, and the artery secured with the aid of an assistant, before the compression is removed from the bleeding spot, *e.g.*, by transfixing the tissues underneath and tying on each side of the compression, like a pedicle.

Should gangrene ensue after ligature, and spread rapidly, amputation must be performed at the seat of ligature; but if it involves only one or two fingers or toes, or spreads slowly, a line of demarcation may be waited for before amputating, the gangrenous part being kept in the meanwhile aseptic in the way suggested under *Gangrene*. The anastomotic circulation will meanwhile improve.

Traumatic aneurysm.—Two forms are described, the diffused and the circumscribed.

The *diffused* is practically a ruptured or wounded artery with extravasation of blood into the tissues. There is no attempt at the formation of a sac, and the term aneurysm applied to it is misleading. (See *Ruptured Artery*, p. 270.)

The *circumscribed* may be formed in several ways, as already stated under *Rupture and Wounds of Arteries*. Thus—1. After a bullet wound or stab an artery may be wounded, pressure be applied, the external wound heal, and blood slowly escape into the tissues; or the artery may be wounded, heal, and the cicatrix subsequently yield. An artery may be wounded, but not penetrated, and the uninjured coat or coats may yield to the pressure of the blood. 2. An artery may without external wound be punctured by a fragment of fractured bone, or torn in reducing a dislocation, and blood in either case be extravasated into the tissues. In all of these cases the soft tissues around become condensed and form the sac of the aneurysm. Where the aneurysm is produced by the yielding of any portion of the arterial coat this at first will form the sac, but sooner or later it will give way, and the sac will then be formed by the inflammatory condensation of the soft tissues around, as when the blood escapes directly into the tissues. The course, termination, and signs of a circumscribed traumatic aneurysm are similar to those of an aneurysm from disease.

Treatment.—The artery may be tied immediately above the sac, or the sac may be laid open and the vessel tied above and below. Recently traumatic aneurysms have been treated by extirpation. The sac is cut down upon, the artery on the proximal side tied in two places and divided, the sac dissected up intact, and the artery on the distal side secured. We have during the last few years treated many cases in this way. The wounds healed by the first intention.

When due to a modern *small rifle bullet*, an aneurysm which is not enlarging may be watched. It may disappear spontaneously or the anastomotic circulation improve, and then either a proximal ligature or an extirpation may be done.

Arterio-venous aneurysm is a pulsating tumour depending

upon an abnormal communication of an artery with a vein. There are two kinds: in one the communication between the artery and vein is direct (Fig. 107, A), and the arterial blood is forced into the vein at each beat of the heart, causing its walls to be dilated into a fusiform or sac-like swelling (*aneurysmal varix*); in the other (Fig. 107, B), the blood passes first into a small aneurysm formed by condensation of the tissues between the artery and vein and thence into the vein, the dilatation of the vein being consequently less than in the preceding variety (*varicose aneurysm*). Both forms rarely occur from disease, but are usually the result of a bullet wound, injury, or stab, wounding the walls of both vessels where they lie side by side. The lesion was of common occurrence at the bend of the elbow when venesection was in vogue, the lancet passing through the median basilic vein and bicipital fascia into the subjacent brachial artery.

FIG. 107.—Diagram of arterio-venous aneurysm. A. Aneurysmal varix. B. Varicose aneurysm.

Arterio-venous aneurysms have been of common occurrence during the late war, caused by high-velocity rifle bullets of small calibre—in the skull, at the back of the orbit, under the jaw, at the root of the neck, in the axilla or groin, above and below the elbow or knee, also in the hands and feet.

Signs. — An aneurysmal varix pulsates without forming a marked tumour, except that, owing to the partial obstruction, the artery above is dilated and thinned, whilst there is a smaller pulse beyond. The vein is dilated and pulsates. There is a peculiar noise or bruit and a whirr, compared to the buzzing of a fly in a paper box. In varicose aneurysm a pulsating tumour gradually develops, with an ordinary aneurysmal bruit and marked venous obstruction. These aneurysms increase but slowly, and do not tend to burst, extravasate, or cause gangrene. The varix may remain stationary for a long period. But the affected limb gradually becomes more swollen, œdematous and painful, with muscular wasting, especially in the case of the varicose aneurysm. In the neck the noise is conducted up into the head, and, as in intracranial aneurysm, is continually ringing in the patient's ear. Some recent cases caused by rifle bullets have shown a tendency to spontaneous subsidence, but, on the other hand, after a stab, there may be a rapid enlargement.

Treatment.—Rest and pressure are of no permanent service; they merely relieve pain and check developments. Some cases have been relieved by proximal ligature only. This especially applies to intracranial aneurysm, but also to some bullet injuries in the limbs.

Generally, the artery should be tied above and below, and the vein let alone; or if there is free hæmorrhage from the veins not checked by pressure, a lateral ligature may be applied. Only if unavoidable should the vein also be ligatured above and below. One of us (Walsham) successfully tied both the femoral artery and vein in Hunter's canal for a rapidly increasing varicose aneurysm, due to the puncture of the thigh by a falling bistoury

INJURIES OF VEINS.

Rupture or subcutaneous laceration of a vein occasionally occurs from causes similar to those producing rupture of an artery—an accident, moreover, with which it is frequently associated. When the vein is of large size much blood may be extravasated into the tissues, and may produce gangrene by pressure on the vessels carrying on the collateral circulation, though such a result is much less common than after rupture of an artery. The blood, except when the extravasation is large, is usually absorbed, but may break down and suppuration ensue.

Wounds.—Punctured and incised wounds when small and parallel to the long axis of even large veins readily heal by adhesive inflammation without obliteration of the lumen of the vessel. At times, however, a clot may form in the wound, and successive layers be deposited upon it until ultimately the vein is occluded. When a vein is completely cut across, as in amputations, it usually collapses as far as the next pair of valves, a clot forms as high as the first collateral branch, and the vein becomes permanently occluded in a way similar to that described under *Healing of Wounded Arteries.* In consequence, however, of the vein wall containing less elastic and muscular tissue than an artery, bleeding sometimes continues unless stopped artificially.

Treatment.—When the wound is a mere puncture in the continuity of the vein, unless it is found that pressure will control the hæmorrhage, the coats should be nipped up by forceps and a lateral ligature or suture applied, so that the lumen of the vessel will not be obliterated. If a vein continues to bleed during an amputation it should be tied like an artery. A large wound, or one made in the transverse axis of a large vein, necessitates ligature of the vein in two places and the division of the vessel between the two ligatures.

The *dangers of wounds of veins* are :—(*a*) *Immediate.* 1. Hæmorrhage. 2. Entrance of air. (*b*) *Remote.* These are complications depending chiefly on the size of the vein wounded and upon the septic or aseptic conditions attending the injury. They are :—1. Phlebitis. 2. Œdema. 3. Thrombosis. 4. Embolism. 5. Ulceration. 6. Metastatic abscesses in organs connected with the wounded vein. 7. Gangrene; and 8. Secondary hæmorrhage.

Entrance of air into veins is fortunately a rare accident,

commonest in cut throat. It sometimes happens in operations about the root of the neck, where the disposition of the cervical fascia prevents the veins collapsing, and thus allows air to be sucked in during inspiration. Air is known to have entered a vein by the hissing sound during inspiration, the escape of frothy blood from the vein on expiration, the urgent dyspnœa, and the state of collapse into which the patient immediately falls. On listening over the heart a peculiar churning sound can be heard. Death in fatal cases usually occurs in a few minutes, and is due to the admixture of blood and air preventing the circulation through the capillaries of the lungs, and so causing distension and consequent inertia of the right side of the heart. *Treatment.*—The finger should at once be placed over the hole in the vein to prevent more air entering, and a clamp or ligature applied as soon as practicable. Pouring water into the wound has been suggested both as a means of preventing the further entrance of air during inspiration and of allowing that which is already in to bubble out during expiration. The patient should be placed with his head low to insure a sufficient supply of blood to the brain, and for the same purpose the arteries of the extremities should be compressed, whilst injections of ether or brandy should be given subcutaneously to stimulate the heart. Artificial respiration should not be performed till the vein is secured, lest more air be sucked in. If fainting continues saline fluid should be infused and artificial respiration with oxygen inhalations kept up.

To guard against entrance of air when operating, veins should be clamped before division, and in removing a tumour traction should not be made at the moment the vein is severed.

INJURY OF LYMPHATICS.

The anastomosis between lymphatic vessels is so free that no trouble arises from their division, except where the main trunks of the limb meet in the axilla or groin, and except when the thoracic duct itself is injured as in the neck on the left side.

The *thoracic duct* opens into the junction of the left internal jugular and subclavian veins by a sort of delta, hence it is the exception for all these outlets to be included in a ligature, and if a chyle fistula forms, it tends spontaneously to close. The thoracic duct has been ruptured along with fracture of the spine ; the patient died in a few days with the right pleura full of chyle. It has been injured by a bullet, by a stab in the root of the neck, and by operations such as ligature of the subclavian artery, or removal of glands. Chyle escapes, but on account of the number of outlets, also the communications with the vena azygos and the right thoracic duct, the rent may be expected to heal. Meanwhile the external wound should be plugged with gauze.

Axillary lymphatics are most commonly injured in the extensive

removal of the axillary glands for mammary cancer; the result of the lymphatic obstruction is chronic œdema of the limb or elephantiasis. In the *groin* the same result has followed the excision of lymphatic glands. The limb becomes much enlarged by solid œdema, which can be scarcely pitted by pressure; the skin becomes rugose, and vesicles may form and leak lymph, causing an eczema.

Treatment.—Elevation and elastic bandaging in the early stage. If the œdema is very marked, the limb is fomented with water as hot as can be borne, and then massaged.

INJURIES OF NERVES.

Wounds of nerves.—A nerve may be completely or partially divided, and the wound may be of an incised, lacerated, contused, or punctured character.

Pathology.—After complete division of a nerve the divided ends slightly retract, and the portion of nerve below the injury degenerates slowly, and at least to a large extent throughout its whole length (Wallerian degeneration). If it unites naturally, or is united by surgical measures, regeneration slowly occurs. As to the repair of nerves, there is at present a difference of opinion which governs the description of the appearance found. We here follow that given by Mr. Bowlby, recently confirmed by Mr. Ballance and Dr. Purves Stewart. The alternative theory has been generally supported by embryologists and physiologists.

The proximal end.—If the divided nerve remains for a time ununited, the portion of the nerve immediately above the division is converted into a bulbous swelling, or nerve-end bulb. It is very tender to the touch, and when cut out and examined microscopically is found to be composed of connective tissue with numerous young medullated nerve fibres coiled up amongst the fibrous tissue. In tracing the origin of these new fibres, it is seen that by the proliferation of nerve corpuscles and of connective-tissue cells of the endoneurium (Fig. 108, D, 1, 2), the nuclei of which show karyokinesis, numbers of young cells are formed. Some of these cells become neuroblasts, and by elongating become spindle-shaped, and so fuse with one another into new axis-cylinders, whilst others are applied to the axis-cylinders, and develop the nerve sheaths and corpuscles. Other cells become fibroblasts, and develop the fibrous tissue of which the end bulb is composed. The view hitherto favoured by embryologists and physiologists is (Fig. 108, C, 1, 2) that these new axis-cylinders have grown out from the cut end, but, meeting with obstruction, coil up, awaiting a favourable opportunity, such as approximation or the insertion of a graft, a leash of animal suture material, or a decalcified chicken-bone, to grow across the gap made by the injury into the distal segment.

The distal segment.—Degeneration occurs (Fig. 108, B, 2 and 3)

beyond the line of division, the myelin of the medullary sheath breaks up, and this becomes marked after the fourth day, when the medullary sheath is changed into a number of fat globules, which are slowly removed by a process of phagocytosis. Later on the axis-cylinder

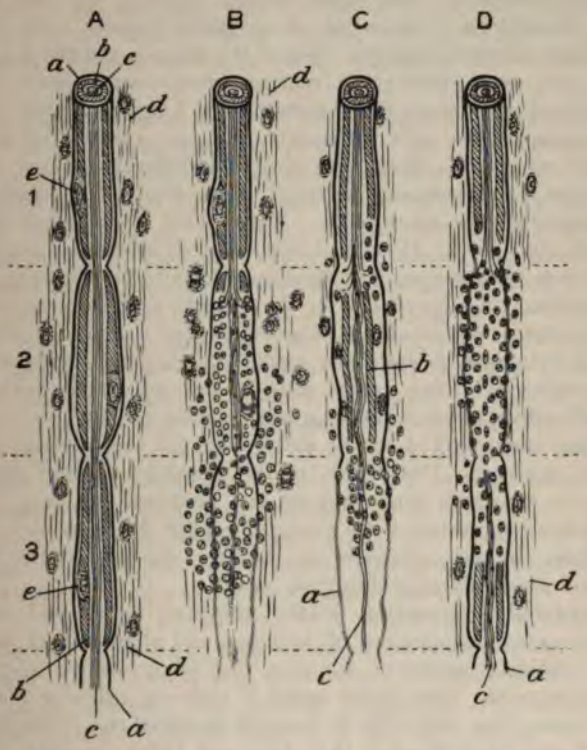


FIG. 108.—Nerve division and regeneration. Diagram in aid of the description in the text. 1. Nerve above the level of division. 2. Nerve just below the level of division. 3. Nerve some distance below the level of division. A. Nerve undivided. B. Nerve divided and degenerating. C. Nerve after division regenerating by outgrowth from the proximal end. D. Nerve after division; regeneration in the peripheral segment. *a*. Neurilemma; *b*. Medullary sheath, and *c*. Axis cylinder degenerating into fat globules; *d*. Connective tissue and cells of endoneurium, and *e*. Nerve corpuscles showing karyokinesis and proliferating to produce small round cells.

becomes beaded and slowly disappears, as well as the neurilemma. Within six hours of the injury there commences an inflammation about the region of the injury, an emigration of leucocytes and exudation of fluid, but this in an aseptic wound is of only transitory duration, although where suppuration occurs it may further destroy the cut ends of the nerve.

Regeneration is carried out by the fixed cells, the nerve corpuscles

and the connective-tissue cells of the endoneurium. About three days after the division (Fig. 108, B, 2, 3) neurilemma corpuscles and the connective-tissue cells show active karyokinesis. The rapid division of these cells produces a number of small round cells, which invade and replace the degenerating nerve fibres. By their phagocytic property, they ingest myelin globules and also inflammatory leucocytes. Some of these newly-formed cells become neuroblasts, others fibroblasts. Not all the fibres in the distal segment die at once, even although it remains completely separated from the proximal end; some fibres persist for a long while, but if there is no union of the ends ultimately, say two years after division, all fibres completely disappear, leaving a connective-tissue strand. But in the distal segment, although still ununited, a regeneration to a certain degree takes place. Some three weeks after division (see Fig. 108, D, 2, 3), neuroblasts, derived as above mentioned, are found to be becoming spindle-shaped, and to be arranging themselves end on, then by fusion to be transformed into young axis cylinder fibres, whilst other neuroblasts are wrapped round the new axis cylinders to form the medullary sheath, neurilemma and nerve corpuscles. New nerves thus formed are found fairly complete after five months, not especially close to the cut end, but are rather more marked in the distal segment some distance away from its cut end. The distal cut end develops a small bulb, not differing in structure from that on the proximal cut end. If the ends continue ununited, these young fibres for the most part remain incomplete, the axis cylinders are beaded, the myelination incomplete, and gradually they disappear again.

The partial regeneration in the ununited distal end may be regarded as an anticipation of re union, and affords an explanation of the rapid recovery of function following suture of nerves, much more rapid than could occur if the axis cylinder fibres had to grow down (Fig. 108, C, 2, 3) from the proximal end. The development of new nerve fibres in the distal end before re-union suggests the theory that a nerve consists of partially independent segments, the nutrition of each internode being largely controlled by the nerve corpuscles or nucleus of the neurilemma, which can undergo rapid division and produce neuroblasts. A negative point in favour of this theory is the absence of regeneration in the spinal cord, where the fibres have no neurilemma and nucleus.

Those who hold to the central origin of all nerve fibres have regarded the fibres found in the ununited distal segment as non-degenerated or only partly degenerated fibres, and the rapid recovery of sensation after re-union as due to nerve anastomosis, while the full recovery of motor power is delayed until (Fig. 108, C, 2, 3) axis cylinder fibres have grown down again from the proximal end and have secreted a medullary sheath, or have joined up to old undegenerated fibres as electric wires are joined.

The foregoing statements must be regarded as provisonal; facts which now seem to support the central theory or, on the other hand, the segmental theory, will doubtless, with further observations, fall into line with one another.

When a nerve is only partially cut across, the divided portions may unite in the way above described, or they may become involved in the scar resulting on the healing of the soft tissues, and then prove a source of much irritation to the rest of the nerve.

The effects of division of nerves.—(1) Paralysis of motion and sensation of the parts supplied by the nerve. (2) Subsequent wasting, atrophy, and fatty degeneration of the paralysed muscles. (3) Certain trophic changes in the tissues whose nutrition is presided over by the injured nerve, such as a glazed, smooth, cold, and bluish-red condition of the skin, falling off of the hair, cracking and deformity of the nails, local ulcerations and gangrene of the fingers, etc. (4) A marked diminution of the temperature of the part, which may be preceded for a few days or even a few weeks by a slight increase of two or three degrees. (5) Affections of the joints resembling rheumatism, and apt to terminate in more or less complete ankylosis. (6) Ascending neuritis, which is attended with severe pain in the cicatrix, pain shooting up the nerve, and pain in the area of its distribution; and (7) Very rarely, changes in the nerve centres of a functional or of an organic nature.

Signs.—The immediate symptoms are loss of function in the parts supplied by the nerve, viz., muscular paralysis, local anæsthesia, or loss of special sense, according as a motor, sensory, or nerve of special sense is injured. In the case of a mixed nerve both motion and sensation will be lost; but sensation in some instances may be partially restored in a few days through anastomosing branches from other nerves. The remoter symptoms are wasting of the muscles, and the trophic changes of the skin, nails, etc., already alluded to, and sometimes pain in the cicatrix, and in the course of the nerve and its peripheral distribution. The muscles exhibit to electrical tests the *reaction of degeneration*, *i.e.*, they do not respond to the Faradic current, but contract on the application of a continuous current of less strength than that necessary to cause the contraction of normal muscles; the contraction elicited, moreover, is slow, long, and tetanic; and the sequence of polar reaction is altered ($ACC. > CCC.$ instead of $CCC. > ACC.$). Their response, however, to the continuous current becomes less and less till they finally cease to contract at all. As a consequence of the degeneration of the affected muscles their opponents undergo shortening, thus producing various deformities, as for example the hammer fingers (*main en griffe*) seen after division of the ulnar nerve, and the resulting paralysis of the interossei (Fig. 109, C).

The *treatment* varies according as the wound of the nerve is recent

or of long standing. In the former case the nerve should be sought in the wound, the divided ends sutured, the limb placed at rest on a splint in such a position that the united ends are not subjected to tension, and every effort subsequently made to obtain healing of the wound of the soft parts by the first intention. If the divided ends of the nerve are lacerated or contused, the injured portions should be cleanly cut away before applying the sutures. If the nerve is only partially divided the divided parts should be sutured. The sutures, consisting of fine China silk, should be passed with a small curved needle through the sheath of the nerve in four or five places. One of the sutures is generally passed completely through the nerve, a quarter of an inch from the divided ends, to ensure a better hold. In every recent wound it should be as much a matter of routine to suture large nerves, if divided, as it is to tie wounded arteries. If the nerve does not unite, an attempt may be made to procure union after the wound has healed, as may also be done in long-standing cases of non-union, though many months or even a year or two may have elapsed. An incision over the ununited ends should be made parallel to the nerve, the bulbous upper end of which can generally be felt through the soft tissues. The ends, which may have retracted so as to be as much as an inch or more apart, should be sought, the bulbous end shaved away little by little with a sharp scalpel till plenty of nerve fibres are seen on the surface of the section, the lower end also refreshed, and the two united in the manner described above, the proximal end being if necessary stretched a little. Where the ends are embedded in much cicatricial tissue they should be freed by careful dissection, and when much separated stretched so as to bring them into apposition. If the nerve is only partially divided, and the divided portions are bound down by cicatricial tissue, the injured segment of nerve, in its entire thickness, should be cut away before applying the sutures. In some instances sensation may return within twenty-four hours of suture; but it may be more than a year in long-standing cases before the function of the nerve is restored, and then not completely as regards fine movements. In the meanwhile the nutrition of the parts supplied by it should be promoted by warmth, and the muscles prevented as much as possible from degenerating by galvanism, massage, friction, and passive movements. The paralysed muscles should also be kept relaxed lest they become over-stretched, and the antagonistic muscles in consequence shortened and contracted.

Transplantation of nerves or nerve-grafting.—The operation of nerve-grafting has now become a recognised surgical procedure. An attempt to restore the function of a nerve in this way may be made where the proximal and the distal ends cannot be brought into apposition, as, for instance, after a portion of nerve has been destroyed in a compound fracture, or after a portion of nerve, damaged by the contraction of cicatricial tissue, by the formation of callus, or by the

growth of a tumour in its substance, has been removed. The graft may be taken from a freshly-amputated limb or from a recently killed animal, or an anastomosis may be made between nerves, the distal end being inserted into a slit made in another nerve trunk. This usually gives better results than the operation of splitting the nerve and turning the flaps into the gap. The conditions for success are :— Great care in dissecting out and handling the nerve, the avoidance of all tension, strict asepsis, and immediate union of the wound of the soft parts.

Subcutaneous rupture of a nerve is rare, but is occasionally met with as the result of a severe twist or wrench. Walsham has seen it three times in the peroneal nerve where it winds round the head of the fibula. It is attended with severe pain at the time of injury, perhaps also referred to the periphery of the nerve, the gradual formation of a bulbous swelling on the nerve immediately above the rupture, and paralysis of motion and sensation in the parts supplied by the nerve. The same effects follow as in division of a nerve in an open wound. The *treatment* is also similar.

In the evulsion of a limb the nerves may be torn away from their roots, as in the instance of a boy in St. Bartholomew's Hospital, whose leg was torn off above the knee, bringing with it the whole sciatic nerve as far as its origin from the spinal cord.

Compression of a nerve occasions numbness and tingling, and, if severe and prolonged, partial or complete paralysis of the parts supplied by it, and the series of changes described in the last section. As examples may be mentioned crutch-palsy, due to the pressure of a crutch upon the large nerves in the axilla ; the dropped wrist, from the involvement of the musculo-spiral nerve in the callus in fracture of the humerus ; the tingling, numbness, and partial paralysis sometimes following dislocations of the shoulder, from the pressure of the head of the displaced bone on the brachial plexus ; the pain caused by the pressure of a tumour on a nerve ; the "pins and needles" felt in the feet after sitting on the edge of a chair, from compression of the sciatic nerve, etc. The *treatment* consists in releasing, if practicable, the nerve from the compressing agent. If a wound of the soft tissues is necessary to accomplish this object, healing without suppuration should be obtained, if possible, as otherwise the nerve may become again compressed by the resulting scar tissue.

Contusions of nerves.—A familiar example of this injury is a blow on the ulnar nerve as it lies behind the internal condyle. There is intense pain at the spot struck, and shooting pains and "pins and needles" in the parts supplied by the nerve. These symptoms pass off shortly, but occasionally they may be more severe and last for several weeks, in which case there is probably some effusion of blood in the nerve. In rare instances ascending neuritis, persistent neuralgia, or even paralysis, and changes similar to those observed after complete division of a nerve, may follow.

Foreign bodies in nerves.—A portion of a needle broken off in a nerve, the lodgment of small shot from a gun accident, etc., may give rise to inflammation of the nerve, persistent irritation and pain at the injured spot, spasm in the muscles, and pain or tingling in the parts supplied by the nerve. Such accidents have occasionally been followed by epileptiform convulsions. Much the same result seems to arise when the nerve has been split by a stab, bullet, etc., without the foreign body actually lodging in it. The *treatment* is to cut down upon and remove the foreign body.

Injuries to special nerves.—*The musculo-spiral nerve* (Fig. 109, A).—This nerve arises from the posterior cord made up of all the nerve roots forming the brachial plexus, and supplies the triceps, all the extensor muscles of the forearm, both the supinators, and the skin on the radial side of the back of the hand, the back of the thumb, index and middle finger. Hence after division there is loss of power of extension of the elbow, whilst flexion is uncertain from the absence of antagonism. The supinator longus places the forearm between pronation and supination and then flexes the elbow. This muscle being paralysed the biceps flexes the elbow in supination. The paralysis of the extensors of the forearm causes wrist-drop and loss of power of extending the first phalanges and the thumb. Supination is lost, so that when an object is grasped firmly the forearm is pronated. The electrical reactions and the loss of skin sensation should be marked out. The musculo-spiral on the inner side of the humerus is liable to be pressed on by a crutch (*crutch-palsy*), the nerve fibres to the triceps generally escaping because they arise higher up; whilst in the musculo-spiral groove it is liable to be torn in fracture of the humerus or caught in the callus. It suffers here also from pressure in sleeping, especially when the patient is placed under an anæsthetic on a hard table, or in the case of a drunken man who sleeps on the ground with his arm beneath him; it may be compressed, too, by tight binding of the arm. It may be also paralysed during over-action of the triceps, in dislocation of the shoulder, and has been injured during the injection of ether subcutaneously behind the arm. Sometimes the nerve to the supinator longus escapes owing to a high origin.

The paralysis usually lasts for some time, but is generally followed by recovery, which is usually complete after some months.

The arm should meanwhile be kept at rest and extension of the elbow avoided, so that there shall be no tension on the nerve as it winds round the humerus, and the wrist requires support. If caught by callus and fibrous tissue in the groove, the nerve may be cut down upon and freed.

The median nerve (Fig. 109, B).—The motor fibres of this nerve arise from all the roots of the brachial plexus, and supply the pronators and flexors of the forearm except the flexor carpi ulnaris and the ulnar half of the flexor profundus, also the abductor, opponens, and outer

head of the short flexor of the thumb and the two radial lumbricales. The sensory fibres supply sensation to the palm and digits except the little finger and the ulnar side of the ring ; also the corresponding dorsal surface of the ungual phalanges.

The nerve is injured by wounds, fractures of the forearm, also in the arm by pressure against the humerus and in unskilful venesection. Then pronation is only possible midway by the supinator longus; the wrist when flexed has a strong tendency to the ulnar side. The thumb is in extension and adduction like the thumb of an ape, and cannot be opposed to the tips of the fingers. The second phalanx cannot be flexed on the first, nor the third on the second, except in the third and fourth fingers by means of the ulnar half of the flexor profundus. The interossei can flex the first phalanx and extend the last two, which they do enough to cause subluxation. The wasting of the thenar eminence is marked. If the damage is at the wrist, flexion of the wrist and distal phalanges persists. Anæsthesia and trophic changes follow.

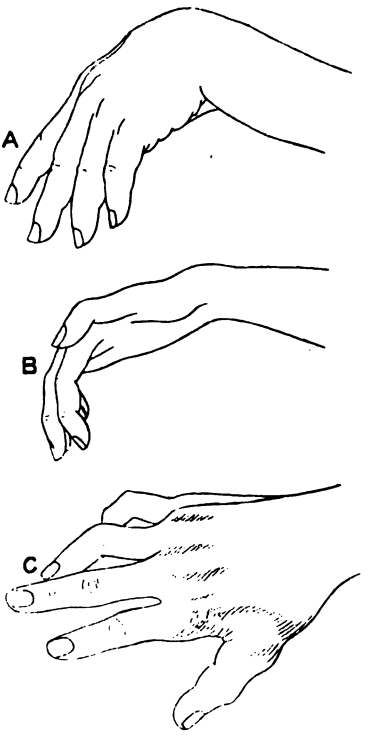


Fig. 109. — Hand after nerve division. A. After division of musculo-spiral nerve. B. After division of median nerve. C. After division of ulnar nerve. (Gowers.)

The ulnar nerve (Fig. 109, C) comes from the last cervical and first dorsal nerve roots and supplies the flexor carpi ulnaris, the ulnar half of the flexor profundus, the muscles of the little finger, the interossei, the two ulnar lumbricales, the adductor and inner head of the short flexor of the thumb. Its sensory area is the ulnar side of the ring and little finger on the palmar, usually the ulnar side of the middle ring and little finger on the dorsal aspect. It is injured in dislocations of the shoulder or elbow, also in sleeping, or in operations on the breast where the arm is placed behind the head ; in wounds, or disease about the elbow-joint, fractures of the forearm, wounds at the wrist. Pressure from leaning on the elbow, and also long continued flexion are causes of traumatic neuritis. In flexion the

hand deviates to the radial side, adduction of the thumb and movements of the little finger are lost, the fingers cannot be flexed at the first nor extended at the other joints, and the opponents of the paralysed interossei produce the claw hand by over-extension of the first phalanges and flexion of the others. The hypothenar eminence wastes.

The ulnar and median nerves are frequently divided simultaneously at the wrist, as by falling through a glass window (see *Cut wrist*). After union there is restoration of all coarser movements, but the finest movements are never recovered completely. Suture should always be attempted, however late, by dissecting up the ends, stretching them a little, flexing the wrist, grafting or joining by strands, or anastomosing the distal end of one nerve into another.

The sciatic nerve and its branches, the external and internal popliteal, may be injured by wrenches, especially the external popliteal as it winds round the head of the fibula, dragging of the foot in the stirrup, gunshot wounds, bullet, shell, or small shot wounds, the last when fired point blank; stabs and cuts, as by a scythe; injuries at operations, as in tenotomy of the hamstrings, or in Macewen's osteotomy; and fractures, especially of the fibula.

In *paralysis of the sciatic nerve* below the origin of the branches to the hamstrings, the leg is extended on the thigh with a jerk by the quadriceps, and the thigh flexed on the trunk by the psoas and iliacus, so that the man swings his leg forwards. The toes touch the ground, then the heel, and then the knee is flexed by the hamstrings. The muscles below the knee waste, and there is a complete loss of sensation in the leg except on the inner and to some extent on the posterior and external aspect which receives its nerve supply from the long saphenous, small sciatic, and short saphenous nerves. There is also loss of sensation of the foot, except along the inner side which is supplied by the long saphenous, and the outer side which is supplied by the short saphenous.

Paralysis of the external popliteal or peroneal nerve causes wasting of the extensors and peronei, with loss of sensation over the dorsum of the foot and outer part of the leg. There is foot-drop, inability to bend the foot and first phalanges upwards, so that the foot is not raised in walking. Talipes equinus results with flexion towards the sole of the first phalanges owing to the unopposed action of the interossei. Severe pain and herpes have been set up by the irritation of fragments of the fibula.

Paralysis of the internal popliteal is shown by the wasting of the calf and the loss of sensation in the sole and over a little of the back of the leg. The heel cannot be raised so as to stand on tiptoe, but the foot lapses into the position of talipes calcaneus with a tendency to flexion of the middle and distal phalanges and extension of the first phalanges, owing to paralysis of the interossei. Its highest branch, viz., that to the popliteus, being involved, there is a loss of rotation inwards of the leg when the knee is flexed.

Other cranial and spinal nerves, also the sympathetic in the neck, may be ruptured or divided by a bullet, and a loss of function result.

The cervical sympathetic nerve.—The complete division of the sympathetic nerve trunk in the neck is indicated on the side of the lesion by a smaller pupil which does not dilate when shaded, but it becomes smaller to light and on convergence; the cilio-spinal reflex by stroking under the jaw is lost, the palpebral fissure is diminished and the eye sunken; there is loss of sweating on that side of the face and neck. Irritation of the nerve has the reverse indications.

SECTION IV.

Disease of Special Tissues.

DISEASES OF BONES AND JOINTS.

The diseases of bones and joints will be considered under the heads of: I. General pathology and non-inflammatory diseases of the osseous system. II. Inflammation of bones and joints; and III. Tumours or new growths.

I.—General pathology and non-inflammatory diseases of the osseous system.

A.—The osseous system in relation to disease.

1. The bones and joints which make up the skeleton, regarded from one point of view, are *passive agents*, rods jointed together which give rigidity, protect viscera and act as levers when pulled upon by contracting muscles. As such they are by force fractured and dislocated; but also as a result of disease the bones may lose their rigidity or become eaten away, or the movements of the joints diminished or altogether abolished.

2. The *histological structure* of bones, including their ends in joints, shows that they are composed of a vascular connective tissue infiltrated by earthy salts; hence in particular, the inflammatory changes, as well as the growth of tumours, follow closely on the lines of those of the softer connective tissues, the differences, owing to the presence of the earthy salts, being more apparent than real.

3. The *development* of bone from fœtal connective tissue being disturbed, the skeleton is affected, either widely or only locally. If in the direction of arrested development there is dwarfing or some limited deformity; if there is development to excess, gigantism, or a local overgrowth having typical characters and coming at last to a standstill, or a continuous atypical overgrowth or tumour formation.

4. From the *physiological* point of view the skeleton constitutes an organ of no mean size, through which a considerable amount of blood is continuously circulated. It is obvious that this circulation must be attended by important interchanges between the blood and the soft parts of bone. A disease causing general disturbance of metabolism, rickets, affects the phosphate of lime salts, which are either insufficiently deposited from the blood or excessively reabsorbed. The peculiar connective tissue forming the bone marrow, filling the cancellous spaces and the medullary cavity, and normally connected

with the formation of red and white blood corpuscles, exhibits under diseased conditions its connection with other lymphadenoid tissues along with alterations in the red and white corpuscles.

5. *Disease commencing in other parts* extends to bones and joints, and this may be local or general. Of the general diseases some may be considered as producing degeneration by the effects of toxic products continuously circulating, *e.g.*, gout; others as producing inflammation through organisms carried by the blood and arrested in the osseous system.

6. *Disease commencing in bones or joints* extends to other parts, locally or through the circulation, *e.g.*, septic inflammation, tumours.

B.—Pathological processes.

1. *The cells of bone.*—The *osteogenetic* cells of bone appear to be derived from that part of the mesoderm which is closely connected with the epiderm, and this may explain why it is that abnormalities of the skeleton are met with co-existing with those of the central nervous system and of the skin. Instances of this concurrence are: anencephaly and acephaly, spina bifida, hydrocephalus, microcephalus, and other forms of congenital idiocy; also congenital skin abnormalities, elephantiasis, mikromelia, hydramnios,—all of which are met with along with deficiencies in the skeleton. Also in the decline of life, when the central nervous system is affected, *e.g.*, by insanity or locomotor ataxia, excessive fragility of bone accompanies the former, and special changes in the joints the latter. The *osteoclastic* cells of the bone marrow appear, on the other hand, to be derived from the portion of the mesoderm most nearly connected with the hypoderm, the bone marrow being developed in connection with the blood-vessels which push their way into the previously solid cartilage of the early skeleton. In other words, they have a similar origin to the lymph-adenoid tissues, and have powers of absorbing not only the normal bone septa, but dead bone and also foreign bone inserted into the medullary cavity.

2. *Arterial circulation in bone.*—A *full* or *slightly increased* arterial supply favours *bone formation*, a *greatly increased* vascularity induces *absorption*. A slight increase of the blood supply is a feature of the growing ends of the diaphyses, the nutrient artery being directed to the end of the bone which grows fastest, the lower end of the femur and upper end of the tibia, the upper end of the humerus and the lower end of the radius. The vascularity of these ends may be so increased as to cause slight pain, "growing pains." An injury which separates the epiphysis from the diaphysis is attended by extravasation of blood, which strips up the periosteum. The capillaries in these situations form wide loops through which the blood flows slowly, and it is doubtless this, along with small extravasations after slight injury, which determines the arrest and development of septic organisms in these situations. The rapid

growth in youths suffering from typhoid fever, also the new formation of bone in connection with chronic inflammation, may be explained in the same way, as due to a slightly increased arterial supply.

But *absorption* follows on *excessive vascularity*. In the endochondral formation of bone in fœtal life the cartilage disappears before the blood-vessels, which penetrate into it from the periosteum. An acute inflammation of bone lasting only a day or two, it is well known, causes rapid softening of bone, as is frequently seen by surgeons when operating. Even a slight injury may lead to bending or even fracture in the vascular bone of a growing youth. If a strain short of breaking is put on the curved rickety bones of a child, sufficient to set up traumatic inflammation and consequently some absorption, in a week later the same bone can be bent or even broken when the same amount of force is again applied. Besides inflammation, an excessive vascularity occasioned in scurvy or by a new growth causes the rapid absorption of bone. A *diminution* in the arterial blood-supply hinders the formation of periosteal bone, whilst the cancellous bone bordering the medullary cavity continues to be absorbed by osteoclasts, and the result is "eccentric atrophy." This is a regular senile change, but it also follows ankylosis of a joint or paralysis; for the consequence of disuse of the muscles is a diminution of their blood-supply and of that of the bone. With the atrophy of the scalp in the aged there occurs a diminution in the blood-supply of the pericranium and outer table of the skull which consequently wastes and irregularities and symmetrical depression at the terminations of the temporal arteries on the parietal bone are the result. Fragilitas ossium and the senile forms of osteomalacia also furnish evidence of a diminished formation of periosteal bone.

3. *Venous congestion is attended by excessive bone formation* in the same way that in soft parts it causes connective-tissue thickening. The veins of the bone are thinner-walled and larger than the arteries; hence the marked thickening of the inner table of the skull in old age, and especially in connection with alcoholism, and when the brain shrinks. For the circulation is slow, and the effect of the shrinkage of the brain is to diminish the intracranial tension and so favour venous congestion, as does cupping of the soft parts. A varicose ulcer of the leg is attended by new formation of periosteal bone, whereas in a malignant ulcer with a free arterial blood-supply bone is rapidly absorbed. A syphilitic node when cut into yields venous blood, whilst in acute inflammation, where there is rapid softening, bright arterial blood escapes when the bone is incised. The thickening of the inner table of the skull in old age from venous congestion is remarkable, for other bones of the face, jaw, femora, undergo eccentric atrophy and become filled with fatty marrow as a result of a diminution of arterial blood supply. Pulmonary osteo-arthropathy, osteitis deformans, and the excessive bone-formation

round joints ending in ankylosis, afford instances of the way in which venous congestion favours the formation of bone in excess.

4. *The nervous influence on the structure of bone* may be considered under the following heads:—

(*a*) *Disturbances of sensation.*—An inflamed bone becomes the seat of great pain, increased by pressure. When operations were done without anæsthesia, the resection of an inflamed joint caused great pain, whilst the amputation-saw cutting through non-inflamed bone was, comparatively speaking, painless. When in trephining the head of the tibia an abscess-cavity was approached, the patient experienced the same kind of pain, or worse pain, than when the exposed pulp of a tooth is touched.

(*b*) *Transformation in the architecture of bone.*—A study of the skeleton of various animals shows that the architecture of each bone has been modelled, both as regards its external form and internal construction, to correspond with the uses of the particular bone and of the limb or part of the skeleton to which it belongs. The internal arrangement of the lamellæ of the adult femur, which is adapted for the erect posture and for walking and running, may be compared with that obtaining in the infant or in an anthropoid ape. The arched lamellæ bear weight, the horizontal and oblique lamellæ act as ties to the arches or form continuations in the bone of the line of the pull of muscles, whilst the more or less vertical lamellæ serve as buttresses. In the bones of the upper extremity the internal arrangement is controlled more especially by the direction of the pull of the muscles, and in this respect human bones may be compared with those of quadrupeds in which the fore limbs, like the hinder, have to bear weight. In a fish, as may be seen especially in the vertebræ of the larger bony fishes, all the skeleton, including the spine, is arranged according to the pull of muscles. The skull, with the orbit and lower jaw, may be considered as modelled for the brain, eyes, and teeth respectively. Now under pathological conditions this normal architecture undergoes transformation. On splitting a bone so altered, a complete revolution in the arrangement of the septa as compared with the normal is to be found. Such pathological conditions as an obliquely-united fracture, a rickety curve of a long bone, or a spinal curvature, are seen to be accompanied by alterations in the internal structure, and this rearrangement of the lamellæ corresponds to the altered conditions in the direction in which weight has to be supported, or the altered directions in which muscles pull. Shrinkage of the brain, the loss of an eye or of teeth, is followed by changes in the skull, orbit, or jaw in adaptation. When, in addition to the foregoing considerations, it is remembered that the architecture of bone starts its development in the fœtus, where neither the weight of the body nor the pull of the muscles is yet in action, a control over the architecture of the bone by the central nervous system is further emphasised.

(*c*) *Trophic influence.*—A normal "tonic" influence on the nutrition of bone appears to be exercised, a disturbance of which is followed by atrophy or hypertrophy. Thus morphœa may affect the skin of the face in the distribution of the fifth nerve, and be accompanied by atrophy of the bones beneath. In leontiasis ossea there is an irregular hypertrophy of the bones of the face in the area of distribution of the fifth nerve. In connection with locomotor ataxia, in quite early stages, a rapid absorption of bone, *e.g.*, of the upper third including the head of the humerus, may occur, or the joint-ends of bones, such as the knee, are absorbed, and the joint becomes loose, or atrophy occurs in the shaft of a long bone and results in spontaneous fracture. Yet, at the same time, irregular outgrowths of bone may appear around the joint surfaces, so much so as to neutralise the excessive mobility consequent on the absorption, or indeed to produce ankylosis. Thus there is evidence in connection with bones and joints, of "trophic ataxia." In other diseases the effect of disorders in nerve trophic influence is seen, such as syringomyelia and epilepsy, in which spontaneous fractures, etc., occur also in peripheral neuritis which may cause deformity of joints by excessive formation of bone.

(*d*) *Symmetry of disease* affords further evidence of nerve influence, instances of which are furnished in connection with bones and joints as regards inflammation and tumours, both in men and animals.

5. *Bone marrow*—(*a*) *Gelatinous marrow*, the primitive mesoblast from which bone is derived, is a translucent, gelatinous mucin-containing substance in which are cells with branched processes; and this mesoblast, on the one hand, is converted into cartilage, by the cells surrounding themselves with a material containing chondrin, or, on the other, becomes vascularised and forms fibrous tissue, whilst the cells become the osteogenetic cells of the perichondrium. This gelatinous material may reappear in tumours, also in the gelatinous marrow which forms in old age and in wasting diseases, starvation, phthisis, renal disease, pulmonary emphysema, cancerous cachexia.

(*b*) The *red or lymphadenoid* marrow, vascular and rich in cells, forms most of the marrow of the fœtus. The cells are either erythroblasts, *i.e.*, nucleated cells, containing hæmoglobin, or colourless nucleated small round cells, precursors of the white corpuscles, or multinucleated giant-cells, or osteoclasts, having to do with absorption. After birth the red marrow gradually disappears from the shafts and then from the cancellous ends of the long bones, being last of all found in the upper end of the humerus and femur. It persists longer in the flat bones and in the skull, and in adults appears to be the sole manufactory of the red corpuscles. Hence the appearance of the marrow undergoes changes in connection with blood diseases. Thus an increased vascularity and an increase of imperfectly developed nucleated red cells attends pernicious anæmia, so

that the marrow of a long bone comes to resemble raspberry juice. In leucocythæmia, lymphadenoma or lympho-sarcoma masses of lymphadenoid tissue with blood extravasations either fill the medullary cavities or form scattered foci in the bones. Also in general inflammatory conditions red marrow with extravasations of blood appear in connection with the invasion of the bone by pyogenic and other organisms.

(*c*) *Fatty marrow.*—The yellow marrow which fills the long bones and gradually most of the remaining bones of the adult must not be regarded as entirely identical with connective-tissue fat, but rather with the fatty masses which replace the thymus and lymphatic glands, for under circumstances, as mentioned above, the yellow reverts to the red form. It is indeed red marrow in a stage of quiescence. In eccentric atrophy, especially in osteomalacia, the whole bone becomes a shell filled with yellow masses. In senile and wasting disease the fat is absorbed and the marrow then becomes gelatinous.

(*d*) *The giant-cells*, or myeloplaxes or osteoclasts, are found in Howship's crypts, bordering on the marrow-cavity. They show amœboid movements on a warm stage, englobe carmin injected into the medullary canal, and some carrying the carmin enter the blood stream and deposit the colouring matter in the lungs, liver, spleen, and kidneys. This shows that there is a ready exit from bone. These cells are important features in bone absorption, in myeloid sarcoma, and in some cases in which an excessive number of multinucleated giant-cells are found in the blood.

6. *Atrophy of bone.*—(*a*) *Eccentric atrophy* proceeds from the marrow-cavity outwards by lacunar absorption. The external appearance of the bone may not be altered, but on examination of the cavity this is found partly or throughout much enlarged, the compact substance outside it remaining as a mere shell. It is filled with fatty marrow, whilst the multinucleated giant-cells or osteoclasts are increased in number. They decalcify the septa and remove the organic remains by phagocytosis. Thus the process is an exaggeration of normal resorption. The result is that the bone is much decreased in weight and is weaker, so that spontaneous fracture is common. Eccentric atrophy especially occurs in old age and from disuse.

(*b*) *Concentric atrophy* is more local in its occurrence, a lacunar absorption causing the bone surface to become worm-eaten in appearance, or an excavation takes place. Inflammatory affections, new growths and aneurysms are common instances. A more general concentric atrophy occurs in the bone of an amputation stump, causing it to become conical, pointed.

(*c*) *Eccentric and concentric atrophy occur together.*—Whilst atrophy from disuse is largely eccentric, some concentric atrophy is seen, so that the circumference of the bone is reduced by, say, one third as compared with the opposite side.

Osteoporosis is an atrophy which starts by widening of the Haversian canals, so that compact bone becomes cancellous, whilst the external shape and the size of the medullary cavity remain comparatively unaltered. Or it may be combined with eccentric and concentric *hypertrophy*, the bone increasing in circumference and the medullary cavity filling up, the whole made up of cancellous porous bone (see *Osteitis deformans*).

Senile atrophy is especially marked in the flat bones, skull, scapula and pelvis. The parietal bones, and to a less extent the occipital, may be so thinned by a disappearance of the outer table and the diploë as to appear rough, translucent or like parchment, or exhibit irregular depressions. The bones of the face become thinner and lighter, the prominences diminishing; the lower jaw loses much of its angle; whilst the ribs and certain parts of the long bones become more fragile.

Neuropathic atrophy is largely eccentric, also to a less degree concentric, with peculiar changes about joints. It occurs in diseases of the spinal cord and after nerve divisions.

Pressure atrophy is a local lacunar absorption. Excessive brain tension, the Pacchionian bodies, tumours and cysts may absorb the skull from within, or an aneurysm in the posterior mediastinum may slowly erode the anterior surface of the vertebræ.

Inflammatory absorption has been referred to under *Arterial Circulation*, and the subject will recur under *Inflammatory Affections*.

7. *Hypertrophy of bone.—Sclerosis—Hyperostosis.*—The new formation of bone under pathological conditions closely imitates the normal formation of bone in membrane. It is brought about by proliferation of the cells of the osteogenetic layer of the periosteum, the nuclei showing karyokinesis. To a less extent, as in the case of the skull, osteogenetic cells appear in the red marrow and apply themselves to the septa and form new bone by apposition. Thus the hypertrophy may be concentric or eccentric, or both. (*a*) Sclerosis of bone (Fig. 110).—Previously existing cancellous septa have formed upon them by apposition layers of new bone until the bone becomes compact with more or less regularly formed Haversian systems, so that the weight of the bone is much increased. (*b*) Hyperostosis is the name applied to a bone hypertrophied both by periosteal and by endosteal new formation of bone. (*c*) Exostoses, or if small osteophytes, are local formation of new bone on the surface, which may be membranous in formation, or if arising near the epiphysial ends cartilaginous. (*d*) Enostosis implies a local formation of new bone within the old. (*e*) Osteoid or chondroid tissue is a more irregular bone formation resembling the inter-Haversian portions of normal bone. Each osteoblast surrounds itself either with lamellæ of fibrous material in which lime salts are deposited staining deeply with carmin, or with a hyalin substance staining with logwood. Such tissue appears especially in connection with new growths.

C.—General non-inflammatory diseases of the osseous system.

Osteogenesis imperfecta.—Intra-uterine defects in development.—(*a*) *Achondroplasia* (Fig. 111) is the name commonly used for a peculiar kind of dwarfing as a consequence of the arrested development of the endochondral bone formation in the shaft of the long bones. The diaphyses remain extremely short, whilst there is an excessive and irregular thickening at the epiphyses with the formation of very hard bone. The long bones fail to grow in length, and a microscopical examination shows that there is an almost complete absence of the epiphysial columns of cells, or each column is reduced to one or two cells. The long bones in

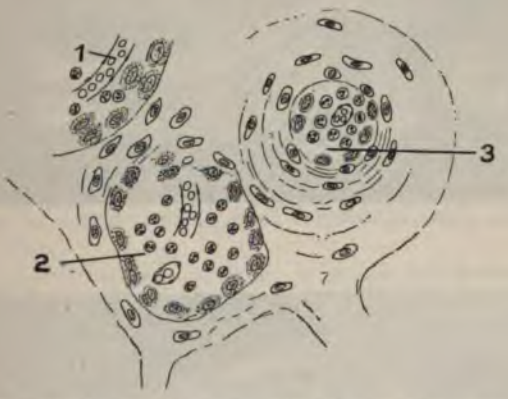


Fig. 110.—Sclerosis of bone. Osteoblasts, cells with oval nuclei surrounded by some granular protoplasm and dividing indirectly, the nuclei showing karyokinesis, are to be distinguished from leucocytes emigrating from vessels, 1, and forming small round cells, 2. The osteoblasts form bone by apposition concentrically, and in densely sclerosed bone the Haversian canal, 3, may come to be entirely filled up.

extreme cases tend towards the shape of dumb-bells, wide at the joint ends, narrow in the shafts. Supposing a child to live, as happens in the less extreme cases, both legs and arms may be equally or unequally affected. The arms (Fig 111) are short, so that when placed by the side they do not reach the iliac crests, whilst the hands are spade-like with stumpy fingers, owing to the shortened metacarpals and phalanges. The head appears of normal size and the trunk of full length, whilst the legs may be very short, so that when standing the appearance is that of a dwarf. When sitting, the length of the trunk prevents the dwarfing from being so apparent. The head has a large vault, but the skull is narrow at its base and shortened, causing the forehead to be prominent, and the bridge of the nose sunken. There is good intelligence, the skin, hair, and sexual organs are well developed, also the

muscles. The gait is waddling, there is a tendency to genu retrorsum, and owing to the shortness of the arms and legs the patient

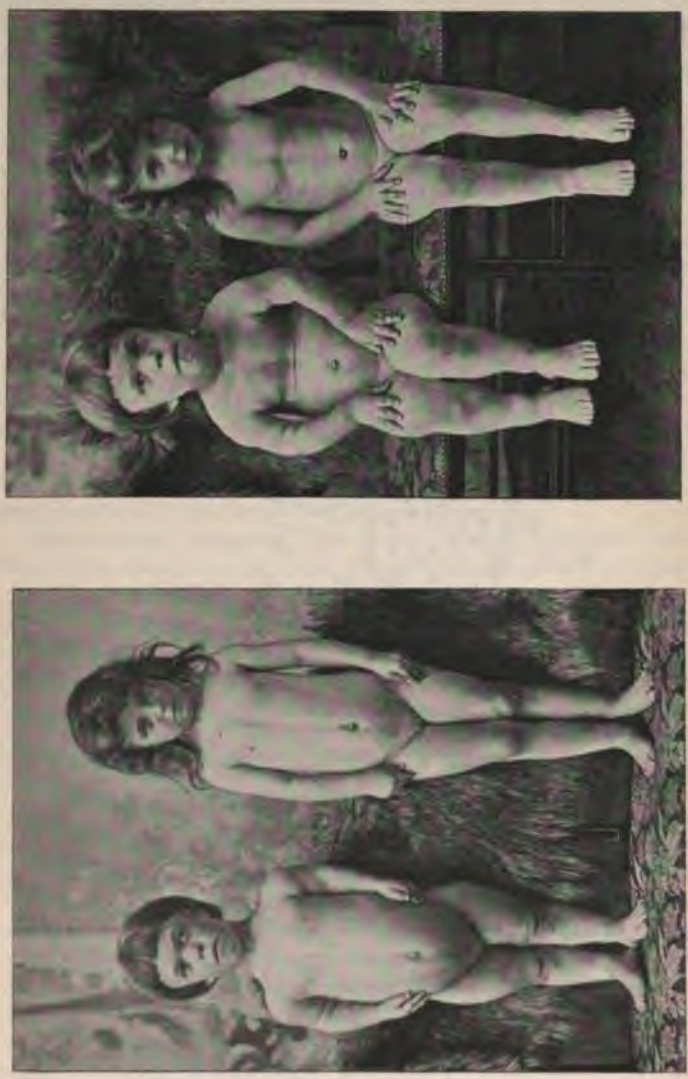


FIG. 111.—Achondroplasia. (Two photographs kindly lent by Mr. W. Turner.) A. The dwarf, aged 10, is standing on the left of her sister, aged 31. B. The dwarf is sitting by her sister.

gets up from the prone position with difficulty, or may complain of pain in the back consequent on lordosis, the waddling and the lordosis being especially the result of the sunken head and neck of the short femurs.

(*b*) *Osteopsathyrosis—Chondromalacia—Chondrodystrophia malacia.*—This affection, known by the above and other names, is characterised by an imperfect ossification of the endochondral cartilage of the diaphysis; the cartilage of the shaft is fully developed, indeed may be in excess, yet it is imperfectly ossified; islands of imperfectly ossified or cartilaginous material remaining in the shaft, which may even undergo myxomatous degeneration. Hence there results multiple intra-uterine fractures. The terms "fœtal rickets," "fœtal scurvy," "fœtal cretinism" are unsuitable, seeing that, as will be mentioned below, rickets, scurvy and endemic cretinism are due to post-natal causes. Nor should terms implying inflammation, *e.g.*, chondritis, be employed, for there is no evidence that the disease is inflammatory in origin or course. When present to any marked degree the child is probably stillborn or lives but a short while. Perhaps in its slightest form, it becomes evident later as essential fragilitas ossium (see p. 310).

(*c*) *Local arrest of development.—Mikromelia* implies an arrest of development of one or more of the limbs, the rest of the body being normal. The limb may be dwarfed as a whole, arrested in some fœtal stage, or the proximal part being well developed, it may suddenly end in a lump resembling the limb-bud of the embryo, or a limb may be almost absent. Such arrests have been attributed to amniotic bands.

(*d*) *Congenital dislocation*, so-called, is an arrested development of a joint. It is especially the hip on one or both sides which is affected, rarely the shoulder. A distinction must be drawn between this condition due to an arrest of development occurring in the head and neck of the femur and the acetabulum and a true dislocation occurring at or soon after birth. There is no evidence as to cause. The condition in the hip is far more common in girls than in boys.

(*e*) *Defects connected with the central nervous system—spina bifida, encephalocele, hydrocephalus, and microcephalus.*—The last named was believed at one time to be caused by a premature synostosis which compressed the brain. But the reverse is the case; the ill-developed brain brings about early synostosis affecting the sutures of the vault and base. In congenital idiocy, the skull may be excessively thin, diaphanous, or, on the other hand, unduly thick, osteoporotic.

(*f*) *Excessive development.—Gigantism.*—There is an excessive but irregular development affecting especially the distal part of a limb resulting in an enlarged hand or foot, with rough, thick skin and œdematous tissue, so-called "congenital elephantiasis." A finger or toe may be excessively long or thick, *macrodactyly*. An undue prolongation of the spine produces a tail-like structure. *Supernumerary thumbs, digits*, or even *limbs* appear, and a tendency to this, *e.g.*, six toes, may be transmitted to some of the offspring. In *polydactyly* the hand is excessively divided, so as to seem to be composed of parts of two hands. In *syndactyly* the fingers are

united by a web or are fused together, or the fingers are so joined together as to form two masses, so that the hand appears forked.

Acromegaly.—Acromegaly, *i.e.*, enlargement of extremities, is the result of disease of the pituitary body. In giants the pituitary body is very large. Some especially powerful men, of great muscular development, exhibit changes similar to some of those occurring in the course of acromegaly. But that which makes acromegaly a progressive and ultimately fatal disease is a new growth in the pituitary body which causes pressure on the optic tract and blinds the patient, followed by other complications

FIG. 112.—Acromegaly in a woman aged 53. The left-hand photograph is from a portrait of the patient several years before. (Copied, by kind permission, from Mr. Silcock's paper in the "Clinical Society's Transactions," 1890.)

incident to the development of a cerebral tumour. Nevertheless psammomatous tumours have developed in the pituitary body without the patient developing acromegaly; also in some cases of acromegaly, cystic hypertrophy, or atrophy of the thyroid, or persistence or hypertrophy of the thymus has been noted.

Acromegaly has been met with at all ages between fifteen and sixty years, both in men and women, running a relatively rapid course in three to four years, or lasting a much longer period, from eight to thirty years. The pituitary body is always affected, either by hypertrophy, colloid degeneration with hæmorrhages, cystic adenoma, glioma or with sarcoma, the last named when the course is rapid.

The *symptoms* may be divided into the early ones included under

the term acromegaly, followed by those connected with pressure on the optic commissure and tracts, and finally those indicative of cerebral tumour.

In acromegaly, the facial aspect is shown by a comparison of the two photographs—the membrane bones of the skull and face become thickened by dense porous bone. The head is enlarged, especially antero-posteriorly ; the chin is prominent, the lower jaw massive, the lower border projecting and the angle becoming more obtuse until the rami are almost in line. The supraciliary ridges and nasal bones are enlarged, the tarsal and nasal cartilages thickened, the skin of the face thickened, warty or pendulous, and the lips thickened, the lower becoming pendulous. The hair is long and coarse. The hands are increased in thickness more than in length, the fingers becoming sausage-shaped. Similar changes occur in the feet. Consequently a woman may have to wear increasingly large gloves and boots up to the largest men's size. The legs and forearms are not enlarged, but male patients may become very muscular. A spinal curve develops, generally kyphotic, due to atrophy of the anterior part of the vertebral bodies, but there is sometimes lordosis or scoliosis. The chest is flattened from side to side, with some enlargement of the sternum, ribs, clavicles and scapulæ, respiration being thereby impaired. The chief bony change is a periosteal thickening with enlargement of the ridges of insertion of muscles and ligaments, osteophytic irregularities on the short bones, and enlargement of foramens. Other organs also undergo enlargement ; the tongue is too large and flabby so that speech is thick, the laryngeal cartilages thicken changing the voice, the penis and clitoris hypertrophy, the vagina is capacious, but the uterus wasted and the catamenia arrested. From pressure on the optic commissure there is progressive optic atrophy and blindness, with paralysis of the eye muscles. As the tumour enlarges, the patient has pain in the eyeballs, headache, and loses the senses of taste and smell. There is later irritability and loss of muscular power, followed by other signs of cerebral tumour. Treatment with thyroidin may give some relief to pain.

Cretinism. — *Endemic cretinism* is an infantile affection, not congenital, for the children of goitrous parents, living in a goitrous district, are born healthy, and only show signs of cretinism after some months. All evidence tends to limit the cause of endemic cretinism to the water. Goitrous parents who move from an infected district have children who do not become cretins, whilst conversely children born to healthy parents who go to live in a goitrous district may become diseased. The fœtal bone diseases above alluded to have often been called fœtal cretinism, but they do not occur with any greater frequency where goitre is endemic than in those districts where goitre is only sporadic. The cause of *sporadic cretinism* is unknown. The thyroid gland is diseased or may be even absent before birth, so that it is doubtless the case

that sporadic cretinism is often congenital. The characteristic, therefore, of cretinism, whether endemic or sporadic, is disease of the thyroid gland; and bone changes should not, unless the thyroid gland is diseased, be termed cretinous. Of the changes in the skeleton due to cretinism, the less severe type consists in regular dwarfing, with delayed development both of mind and body. A patient may be seen between twenty and thirty looking like a boy of less than ten; the epiphysial lines, as seen by the *x* rays, are still cartilaginous, the permanent teeth not all erupted, the sexual organs undeveloped, the mind that of a child. Yet, especially under thyroid treatment, such a patient long past twenty may grow and his mind develop. In fact, the disease is similar in its effect to that of removal of the thyroid gland. The thyroid gland having been removed from a boy of ten, an arrest of growth and development, mental and bodily, took place, so that eighteen years afterwards the boy was no taller than at the operation. In the more severely affected patients, from endemic cretinism, there is a marked arrest of the development of the bones in length, with bending or excessive fragility of bone. The epiphysial ossification ceases, the cells no longer proliferate, but may become vacuolated, and fibrous tissue invade the epiphysis growing in from the periosteum. Improvement follows the administration of thyroidin in doses short of causing thyroidism.

Scurvy.—*Scurvy* is a post-natal affection; no fœtal disease can be identified with it. Whether it occurs in an infant or later, it is due to want of fresh food, fresh milk, vegetables, fruit. According to one view it is the result of poisoning by products formed in stale and decomposing foodstuffs. The disease appears to be quite distinct from rickets, so that the term scurvy rickets is inappropriate. It may arise in an infant fed too exclusively on artificial foods or preserved milk. Sterilised milk loses some of its antiscorbutic properties. In adults, scurvy arises from a diet of salted, stale, or decomposing foods, without fresh vegetables or fruit, *e.g.*, from living most of the winter on bread and salt butter. Affected children show sudden painful swellings about the ends of the long bones, especially the lower end of the femur and upper end of the tibia, without at first inflammatory signs, but accompanied by anæmia and spongy gums. The swelling may fluctuate, and yield on aspiration blood-stained fluid. An abscess may form containing blood and pus.

In more severe cases the extravasation of blood extends along the shaft of the bone, stripping up the periosteum until the whole diaphysis is bare, and extending in between the epiphysis and diaphysis, causing a separation. When many bones are affected, the child is very anæmic, with an earthy look, has marked spongy gums, hæmorrhages from mucous membranes, and dies. Post-mortem, widespread separation of the periosteum and detachment of epiphyses is seen as a result of the blood extravasation.

Similar subperiosteal swellings occur in older patients and cause a lacunar absorption in the bone beneath, and so fragility of bone and spontaneous fractures. Fractures refuse to unite, blood being extravasated between the ends, and callus formation is delayed, until the scurvy is relieved, when a development of callus sets in. A recently fractured bone which has become firmly united by callus, supposing the patient to begin to suffer from scurvy, becomes disunited by absorption of the callus already formed. The *treatment* is that of the scurvy and anæmia—fresh unboiled milk, potatoes and other vegetables and fruit, with fresh meat or fresh meat juice, also iron. When fresh meat and vegetables cannot be obtained, fruit preserved with sugar, as jam, prevents the occurrence of scurvy in seamen, or in travellers or soldiers on land.

Rickets.—*Rickets* is a constitutional affection of early life, essentially one of malnutrition, especially the imperfect assimilation of phosphate of lime and fat. It is characterised by a softening and curving of the bones, with an impaired general development, and enlargement of the liver and spleen by interstitial inflammation, although some would deem the latter due to other causes, such as inherited syphilis.

Causation.—Improper food and bad hygiene, predisposed to by debility, *e.g.*, resulting from inherited syphilis. Milk is the proper food for the young; the ash of milk is practically identical in composition with that of the skeleton. The lime in it is indispensable for ossification, and cannot be substituted by allied substances such as barium or strontium or magnesium, and there is a higher percentage of lime in milk, viz., 1·7 per cent., than in a saturated solution of lime water which has but 1·3 per cent. The phosphates are required, not only to combine with the lime in bone (lime in bone ash 35·8 per cent., phosphoric acid 39·8 per cent.), but also for the phosphorus-containing compounds in nuclei and it is upon nuclei that the activity of cells, including the osteogenetic cells, depend. Leguminous plants contain only $\frac{1}{10}$, the yolk of egg $\frac{1}{5}$, and bread and meat $\frac{1}{20}$ of the lime in milk. But in rickets also there is a mal-assimilation of fat, which in many cases is hindered in its absorption by the intestinal catarrh set up by improper feeding, or is actually deficient in the food, as when the mother's milk is poor or she suckles too long, or the child is fed on indigestible, and so irritating, starchy foods. The improvement in the mother's health, the administration of milk rich in fat, cod-liver oil, bacon, are, therefore, means of preventing or arresting the affection. Fat added to the lean horseflesh eaten by the mothers has prevented rickets in young lions; oilcake given to ewes avoids the occurrence of rickety lambs. The assimilation of fat is closely connected with the maintenance of the bone salts. During starvation there is a marked excretion of lime and phosphoric acid by the urine, both in men and animals, and in the latter, when starved,

14 per cent. to 17 per cent. of the weight of the bones is lost before death. Cold, damp, and deficient ventilation may tend to promote not only intestinal disturbance and mal-assimilation, but also an excessive expenditure of fat. Monkeys and other tropical animals kept under artificial conditions in this country show a marked tendency to rickets, a disease from which they do not suffer in their wild state. On the other hand, rickets is rare among the poor in climates warmer than our own, as India, whether from the cheapness of fatty, oily foods, such as maize, etc., or the more general use of milk, or the smaller expenditure of fat on heat production. A wasting disease, such as inherited syphilis, by removing fat may set up the excessive loss of lime salts already mentioned. But beyond this, in all severe cases of rickets there is a marked febrile disturbance which may be supposed to be of the nature of a toxinæmia, the toxins arising from the ill-digested food in the inflamed intestine, or in the blood in connection with the disturbed metabolism. The causes producing the rickets ceasing, a reaction follows, in which ossification may go on to excess.

Pathology.—The bone changes are—(1) Decalcification of pre-existing bone, which then yields to the weight of the body and the pull of muscles, giving rise to deformities. (2) An increased absorption, by which cancellous bone from the medullary cavity outwards is replaced by red marrow, a vascular tissue composed of small round cells, and the compact bone of the exterior is rendered cancellous by lacunar absorption. (3) An imperfect bone formation both at the epiphyses and by the periosteum. The intermediate semi-translucent, bluish zone of ossifying cartilage between the epiphysis and diaphysis is thicker, and irregular in outline. Vascular tissue encroaches upon the hyalin cartilage, and islands of uncalcified cartilage appear in the soft, spongy bone of the end of the shaft.

At the epiphysial line the columns of cells are increased in number, with some of the cells large and vacuolated, and between the columns penetrate vessels both from the shaft and from the periosteum along with young connective tissue, and grow irregularly into the hyalin cartilage. The laminæ of the hyalin cartilage between the columns of cells do not calcify, but partly remain unaltered, and partly form irregular septa of a fibrous structure enclosing vascular marrow. The breadth of the epiphysis and of the end of the diaphysis is increased by the irregular ossification causing the enlargement of the ends of long bones, and the beading of the ends of ribs, but growth is really diminished in rate, and rickety children grow up short or dwarfed. The periosteal surface of the bone is rough, covered by a thickened vascular periosteum forming spongy bone, with fibrous septa imperfectly calcified, so that, whilst firm enough to resist finger pressure, the bone can be cut with a knife. Towards the medulla new imperfectly ossified septa are

developed, or this osteoid tissue is applied to previously-existing partly-absorbed septa, so that the whole medullary cavity may thus become filled up. The bones generally have a spongy or osteoporotic appearance (Fig. 113). There is not the normal distinction between compact and cancellous bone and medulla in the long bones; in the skull the outer and inner table are no longer sharply defined from the diploë, the skull having a thickened and uniform spongy appearance on section. When the process comes to a standstill, the osteoid tissue becomes ossified to form compact, ivory-like bone to excess.

Clinical symptoms.—When the disease is well pronounced, especially in young children before two or three years of age, there are marked febrile symptoms, sweating of the head and upper part of the body, restlessness, but an aversion to regular movement, and tenderness of the bones when handled; also anæmia and muscular debility, which may almost simulate paralysis. There is intestinal catarrh with diarrhœa, foul motions, a flatulent tumid abdomen, enlargements of lymphatic glands, liver and spleen. The earthy-looking anæmic aspect corresponds to a diminution of red blood corpuscles; the muscles are soft and flabby. The child may be wasted, though after being fed excessively on starch and sugar will appear fat, but pasty. Phosphate of lime may be found in excess in the urine during the early stages, but not to any marked degree, nor later in the illness.

Fig. 113.—A longitudinal section of a rickety femur. (St. Bartholomew's Hospital Museum.)

Deformities.—The *skull* is thickened, often irregularly into bosses, or along the sutures, or it may be thinned where pressure has been excessive. From lying on the occiput the bone may be thinned to the texture of parchment (craniotabes). The bosses on the forehead or parietal bones give the head a square look; the fontanelles are late in closing.

Dentition is generally delayed, or the teeth, if erupted, quickly decay.

The *spine* in young children is kyphotic. There is one long curve backwards; in older children, lordosis or scoliosis may appear.

The *clavicles* are bent in exaggeration of the S-curve; in particular the sterno-mastoids, especially when called into over-action owing to bronchitis, bend up the inner ends of the clavicle so as to resemble a bilateral sterno-clavicular dislocation.

The *thorax* is deformed by the action of the diaphragm, which draws inwards the ribs along its line of attachment, so that there is a sulcus extending from the sternum downwards and outwards over

the lower ribs. This reduces the size of the chest and hinders inspiration, so favouring bronchitis, and the heart may be compressed and the auricles dilated. The *sternum* is thus pushed forwards and produces the deformity known as pigeon-breast; the costo-chondral junctions are enlarged, producing "beading of the ribs" or "the rickety rosary" (Fig. 114). The cartilaginous margin of the ribs is everted, so that their lower edge looks forward, and this border may later become irregularly ossified. The ensiform cartilage and the lower end of the sternum is drawn backwards, so that a hollow is formed in which water will stand when the patient is lying down.

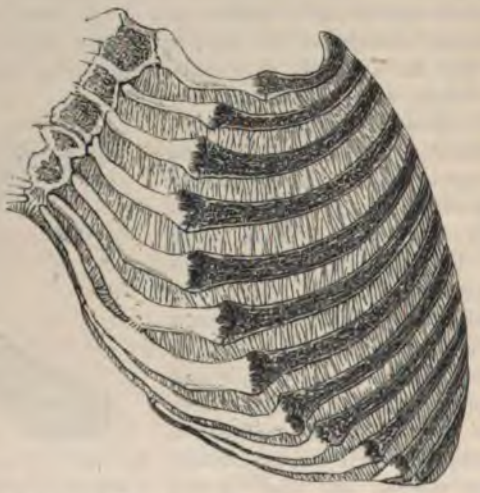


FIG. 114.—The whole of one side of the chest from a rickety child showing the "beading" of the ribs at their costo-chrondal joint (*the rickety rosary*). The ribs are less curved than normal, and the sternum is pushed forward. (St. Bartholomew's Hospital Museum, No. 270 *a*.)

The *pelvis* is deformed by the weight of the spine pressing the sacrum downwards and forwards until the promontory projects beyond the wings, giving the inlet of the pelvis a reniform outline. Or the pressure of the heads of the femora on the acetabula may so push in the sides of the pelvis and the symphysis forward, that the inlet of the pelvis assumes a trefoil or triangular deformity like that in osteomalacia. The ilia are flattened, the pubic arch is widened, the ischia are turned outwards.

Lower extremity.—If the sides of the pelvis are compressed the acetabula are directed more forwards than the normal, and the femora become bent, having a long convex curve forwards and outwards. If this is continuous with a similar curve forwards and outwards of the legs, the result is bow-legs, or genu varum. The lower end of the femur, which is thickened, may bend inwards, the femur tending to

become S-shaped, and so favouring the development of knock-knee, or genu valgum. In such a case flat-foot is likely to persist; the lower ends of the tibia and fibula also are thickened and curve outwards. The shafts of the femur and tibia tend to become scabbard-shaped, with a thick buttress of ultimately very dense bone along the concavity.

At the epiphyses there is bending with irregular growth owing to pressure; the bending of the neck of the femur downwards results in coxa vara. The diminished growth of the epiphyses of the femur and tibia, on the outer side, helps towards causing genu valgum or knock-knee, on the inner side genu varum or bow-leg. A convex curve backwards at the knee results in genu recurvatum, the leg tending to be flexed at the hip until the anterior surface is in contact with the trunk, thus resembling the intra-uterine position of the limbs.

Upper extremity.—The deformities in the upper extremity are less marked, unless the child being too young to walk is allowed to crawl about, when the curves assumed resemble those of the lower extremity, or the fore limbs of a bull-dog, the humerus bent backwards, and the radius pronated and curved forwards at its lower end.

Complications.—Rickety children are liable to suffer from thrush, diarrhœa, bronchitis and hydrocephalus; convulsions, especially laryngismus stridulus, may supervene and prove fatal. There may be tetany affecting the hands and feet.

Inherited syphilis and rickets often co-exist, and the former is a great predisposing cause of the latter. But they are distinct diseases, occurring quite apart from one another. Perhaps inherited syphilis has especially to do with the production of the "natiform skull" or "Parrot's nodes," also with the fibrous interstitial enlargement of the liver and spleen, which may also be favoured by venous obstruction, the result of bronchitis and emphysema. In later life the patient may undergo unusual muscular development, or the deformities may be excessive and require treatment. In some cases the irregular ossification and stunted growth at the epiphyses may later change into the formation of dense bony nodules, multiple exostoses, and these may later still become sarcomatous.

Treatment.—The child requires to be frequently washed to remove sweat, and to be kept warm to avoid bronchitis, but is to be handled as little as possible to avoid pain. Later, during convalescence, it should have abundance of fresh air and sunlight. Regular and careful feeding is the essential point. As a preliminary, thrush must be got rid of by painting and wiping out the mouth with boric acid and glycerine, and the intestinal irritation checked by mercury and chalk powders. The diet should be new milk, only boiled a few minutes and well diluted, given in small amounts and frequently, with the addition of raw meat juice or cream. All starchy food

must be well cooked by baking or boiling. Older children may soon have potatoes with gravy or minced meat, also fresh fruit such as oranges. Cod-liver oil is the most important medicine, and may be regarded almost as a specific; if the child is anæmic, some phosphate of iron may be added. Long sterilised or stale milk, and the various kinds of patent foods composed of starch and sugar must be avoided; also in older children everything that is indigestible, or that cannot be well masticated. The child must be kept off its legs and must not crawl about until the bones are again firm enough. On the other hand, the position in bed must be constantly varied, and if splints are applied these are often changed, lest atrophy from continued pressure ensue.

Late rickets.—This term should be restricted to cases in which the results are characteristic of rickets, whether it be that the disease is insidious and overlooked until the deformity becomes prominent, or is a recrudescence of the disease which existed in early life, or really appears for the first time after ten years of age. The deformities produced may be such as coxa vara or knock-knee. On the other hand, extensive softening of one or more bones with spontaneous fractures or hæmorrhages in patients about puberty are more nearly allied to osteomalacia or scurvy than to rickets. The causation of late rickets appears similar in principle to that of the early form, such as want of food, lack of fat in the diet, cold, damp, and foul air. Girls especially suffer, perhaps owing to menorrhagia and anæmia. One girl was dying of phthisis, another of exophthalmic goitre when the bones were attacked. Special cases in boys about puberty have been attributed to masturbation.

Osteomalacia—Mollities ossium—*Osteomalacia*, a term which should be restricted to affections of adult bones, is characterised by a softening as the result of the removal of the lime salts, whilst the ground substance of the bone remains for a time unaltered. This decalcification (Fig. 115) commences on the surface of the septa and extends towards the centre of the lamina, which may withstand the process for some time. The decalcification leaves the septa composed of a homogeneous or fibrillar material, in some places granular from irregular calcareous collections imperfectly absorbed. The bone corpuscles are partly preserved, or partly disappear leaving gaps. Some disappearance of bone structure also takes place by a widening of the Haversian canals and cancellous spaces owing to the activity of giant osteoclasts.

Forms of osteomalacia.—(1) The commonest and typical form occurs in women in connection with pregnancy, and is related in some way to disturbance of the ovaries. Also it is to some extent an endemic disease. (2) Senile osteomalacia appears in old age, especially in the insane both men and women. (3) A rarer form appears about puberty in girls unconnected with pregnancy, but perhaps with menstruation; exceptionally also in males. (4) Cancerous

osteomalacia is caused by a widespread or general metastatic infection of the skeleton by tumour formation, carcinomatous or sarcomatous, which will be described in that section.

Puerperal osteomalacia.—Rare in this country, it is much more frequent among women of the lower orders in certain places, notably in some of the lateral Rhine Valleys and other parts of Middle Europe, so much so as to be almost endemic. It commences during pregnancy, increases until after labour and suckling, then an improvement may follow, the disease appearing arrested, but it recommences with the next pregnancy, so that each labour finds the woman more deformed than before. And this may go on until the climacteric, when the disease is arrested and the bones may then become harder.

Puerperal osteomalacia especially affects the bones of the pelvis next the femora; the humeri and other bones are less softened and only in advanced cases. The bone becomes excessively vascular, the septa are rapidly decalcified and some are removed, whilst the marrow becomes dark red like the spleen and may show hæmorrhages; at a later stage it is more fatty. The bone becomes reduced to a shell, which eventually disappears, leaving a yielding crinkled leather-like sac composed only of the organic material of bone.

Fig. 115.—Microscopical appearance of a fragment of bone in mollities ossium. (From Rindfleisch.)

Clinical symptoms. — The first signs are aching pain in the pelvis and thighs, often treated as rheumatic. Then there follows inability to stand with bending of the thighs, or a fracture may occur without provocation, and, as long as the disease is active, without showing any signs of repair. The pelvis is deformed by pressure of the hips, so that the sides are convex inwards, the inlet becoming trefoil or heart-shape. The pubes is pushed forwards like a beak, and the pubic arch is narrowed. Thus parturition is rendered difficult or impossible unless the pelvis is quite softened. The shaft of the femur is curved, and the neck yields so that the head is lower than the trochanter. The urine is of uncertain composition; albumen (albumosuria), excess of lime and phosphates, lactic acid, have been found, but by no means uniformly. If the disease is arrested, ossification sets in with some irregular osteophytic formations, especially on the pelvic bones and at the insertion of muscles in the long bones; the fractures are surrounded by an excessive mass of callus. Also there may be some changes in the joints, as in arthritis deformans. This arrest and re-ossification may follow better food and hygiene, arrest of pregnancies, the climacteric, or oophorectomy. Failing this, the woman may die in labour or from dyspnœa and

exhaustion, consequent on the yielding of weakened ribs, or from bladder and kidney infection.

Treatment.—With good food and cessation of suckling the woman may improve, and there may be definite recovery if she does not again become pregnant. The best drugs are cod-liver oil and phosphorus. Removal of both ovaries has been very successful in arresting the disease, but should be recommended only in the well-marked cases. The patients have rapidly regained the power of walking without assistance. Some cases, however, perhaps of a different causation, have remained unimproved by the operation.

Causation of puerperal osteomalacia.—The foregoing considerations show how difficult it is to account for the disease. Its almost endemic character in certain places among women of the lower orders has been referred to bad hygienic conditions, damp, bad food, hard work. In other places it is sporadic. The women are usually very fertile, as if there were in them excessively active ovaries, and from this cause and the recurring pregnancies an excessive vascularity of the pelvic bones is engendered, for as a normal phenomenon of pregnancy an increased blood supply to the pelvis has been noted. Hence the favourable effect of the cessation of recurring pregnancies and of the climacteric, whether at its natural time, or when artificially produced by oophorectomy. Yet, as mentioned before, the removal of the ovaries has not in some cases influenced the course of the disease.

Senile osteomalacia occurs more frequently in the insane, male and female, and affects especially the spine, ribs, skull, and limb bones; one bone may be more particularly affected. Fractures occur from very slight degrees of violence, from stumbling, and getting out of bed, or even from turning in bed or coughing. Asylum attendants have to handle such patients with the greatest caution.

Osteomalacia of puberty.—These are cases accompanied by bending and multiple fractures, the bones presenting the changes peculiar to osteomalacia rather than to rickets. This osteomalacia has been met with in girls about puberty, unconnected with pregnancy or lactation, and in some cases has been arrested by oophorectomy. Similar cases have been met with in males. Malnutrition, such as want of food, anæmia, or some other disease, may have preceded the condition.

Fragilitas ossium.—Multiple spontaneous or pathological fractures.—*Fragility of bone* has many causes. (*a*) It may result from one of the general diseases of bone already described; (*b*) from some inflammatory local disease; (*c*) from some local or generalised tumour formation; (*d*) from senile, nervous and exhausting diseases; (*e*) from essential fragility of bone.

There are some cases of apparently essential fragility of bone, not connected with rickets, scurvy, or osteomalacia. In both boys and girls multiple fractures may arise and recur from very slight

causes and yet unite readily. But the union is liable to be attended by deformity, and the deformities progress and lead to disuse and so to eccentric atrophy in the shafts, which increases the fragility. In some instances an inheritance of this fragility can be traced, and more than one member of the family may be affected. Perhaps the cases are slight and late instances of those described under congenital osteopsathyrosis (p. 299). Perhaps the fragility may be acquired under bad hygienic conditions, etc. Horses and cattle under certain kinds of food, on cold and damp soils, and exposed to bad weather, may develop a fragility of bone. But the fragility may be an early sign of multiple sarcomatous growth in bone, as happened in a case under Mr. Langton, of a boy who fractured his right humerus when throwing a cricket ball at the age of eleven; and in whom after recurring fractures of various bones from slight causes which united, a sarcomatous growth appeared in the right humerus seventeen years after the bone had first been fractured.

II.—Inflammation of Bones and Joints.

Nomenclature.—The inflammatory changes that occur in bones and joints are usually named according to the chief starting-point, although they seldom remain confined to that particular part of a bone or joint. The changes vary according as they are simple and tend to resolution and sclerosis on the one hand, or to ulceration and suppuration, with destructive caries and necrosis, on the other. The course of the inflammation varies according to the specific cause of the inflammation, whether produced by pyogenic cocci or by other organisms, or whether the inflammation extends to the neighbouring soft parts or is the cause of general infection.

As in the soft parts, so in bones and joints, it is the blood-vessels and cells which are actively concerned in the inflammation; the actual bone and cartilage, and also the fibrous tissue, play but a passive part.

Inflammation of a bone generally is called *osteitis*; of a joint, *arthritis*. When, however, it begins or chiefly affects the periosteum, it is termed *periostitis*; when it starts in the marrow, whether in the Haversian canals, cancellous spaces, or medullary cavity, *osteomyelitis*; when it is situated chiefly in the synovial membrane, *synovitis*. Difficulty arises when terms are applied to inflammation commencing near or at the end of a bone. *Epiphysitis* was formerly much used for inflammation, especially septic inflammation near the epiphysial line in the young. But it was found that the inflammation really commenced in the marrow tissue at the end of the diaphysis, hence the term *diaphysitis*, not much adopted. *Chondritis* has been employed for inflammation affecting especially the articular surface, but the cartilage is not the active seat of the

inflammation, which either begins in the cancellous bone beneath the cartilage or in the vascular tissue of the periosteum and synovial membrane round its margin. The term *synovitis* may be used when the inflammation is restricted to the synovial tissue; *arthritis* for a periostitis and osteomyelitis of the joint-ends in combination with the synovitis. *Osteitis* is the more convenient term when the origin or extent of the inflammation is not confined to any particular part of the bone. *Osteo-arthritis* implies an inflammation in which both bones and joints suffer. *Osteopathic arthropathy*, or in combination *osteo-arthropathy*, is used in connection with diseases of obscure origin, combining features both of inflammation and of tumour formation.

Fig. 116. — Chronic periostitis. (From St. Bartholomew's Hospital Museum.)

Inflammation of Bone.

Periostitis is an inflammation commencing in or chiefly affecting the periosteum and the external layers of bone, to which it may remain confined, or it may spread beyond to the centre of the bone, to a neighbouring joint, or to the surrounding soft parts.

(*a*) *Simple acute periostitis* is often traumatic, *e.g.*, due to a kick on the shin, or may be rheumatic, syphilitic, typhoidal, etc. There is an acutely painful and tender swelling, with redness and œdema of the skin when the bone is near the surface, or if the bone is covered by soft parts it can be felt to be enlarged. The pain is increased by anything which favours congestion; thus it tends to be worse at night in bed, and when the limb hangs down. If cut into at this stage, the periosteum is found to be much swollen, œdematous and infiltrated by leucocytes. The blood-vessels are dilated and those of the osteogenetic layer often give way, so that small hæmorrhages are seen. Under these circumstances some lacunar absorption occurs on the surface of the bone, the compact bone becoming cancellous with a rough irregular surface. The local *treatment* consists of cold applications, with rest and elevation, and the general treatment is dependent on the cause.

(*b*) *Simple chronic periostitis* has a similar origin to the acute: slight repeated injuries, muscular strain and over-use, *e.g.*, from long marching, sprains stretching ligaments at their insertions, syphilitic or rheumatic inflammations running a chronic course.

There is (Fig. 116) an increased thickening of the outer layer of the periosteum, new fibrous tissue being formed, and the whole membrane is at the same time raised from an excessive formation of bone by the osteogenetic layer. This new bone, when limited

PLATE I.

Skiagram of chronic periostitis of the lower end of the femur. The diagnosis of the swelling lay between periostitis and a new growth. (Taken by Dr. Hugh Walsham.)

[*To face p.* 312.

in extent, is termed a *node*. The cells of the osteogenetic layer undergo rapid division, showing karyokinesis, and form bone in membrane, which is generally densely compact, differing only from normal bone in some irregularity of the Haversian systems. If the chronic periostitis continues the deeper cancellous bone may become compact, and even the medullary canal be encroached upon. A periosteal node on the skull or other flat bone may consist of spongy cancellous bone. Chronic periostitis causes a dull boring pain generally worse by night than by day, and forms a hard swelling on a bone, not very tender unless firmly pressed. Even when superficial, as on the tibia, there is generally no redness of the skin, but the soft parts may be œdematous, especially over the skull. The diagnosis is made by seeking for the cause; exploration with a grooved needle will exclude fluid, and the *x* rays may aid in distinguishing from sarcoma (*cf.* Plate I. with V. and VI.).

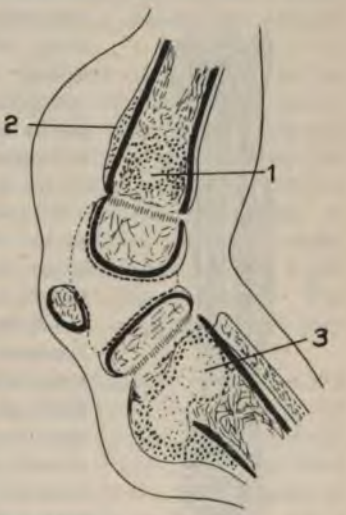


Fig. 117.—Acute infective osteomyelitis and periostitis. Diagram of inflammatory foci in the femur and tibia—1, commencing in the lower end of the diaphysis of the femur above the line of the epiphysis; 2, extending outwards beneath the periosteum; 3, an acute abscess in the upper end of the diaphysis of the tibia, communicating freely with pus beneath the raised periosteum.

Treatment.—Iodide of potassium (grs. x. to xx.) is generally of service, and especially relieves pain and removes much of the swelling if syphilitic, but also does good in other cases. An application of belladonna or opium is required for pain, afterwards mercury or iodide ointment to promote absorption.

(*c*) *Acute infective periostitis* is caused by organisms, in particular by the staphylococcus pyogenes aureus (see p. 60). When the disease commences as such it is commonly due to a septic injury, a punctured wound, or compound fracture. More usually the periostitis follows infective osteomyelitis. In acute pyogenic inflammation there is a rapid emigration of leucocytes and exudation of fluid from dilated vessels, which raises the periosteum from the bone (Fig. 117, 2, 3) and develops an abscess bounded externally by the periosteum and beneath by the bone. Contact with the pus may destroy the osteogenetic cells, whilst the outer fibrous wall proves more persistent though deprived of the power of forming bone, or the pus may burst through the periosteum into the soft parts, or invade a neighbouring joint (Fig. 118). The bone in contact

with the pus becomes converted from compact into cancellous bone, or by ulceration or caries entire septa disappear, producing an excavation. Leucocytes invade the Haversian canals and canaliculi, before which the bony septa disappear, being first decalcified and then removed by phagocytosis. The giant-cells or osteoclasts take part in this absorption of septa, being stimulated into excessive activity by the increased vascularity attending the inflammation.

If, however, the exudation is rapid and extensive, the circulation to a large part of the bone through the periosteum, also through the nutrient arteries, is cut off, the vessels being thrombosed or torn across. Consequently the outer layers of bone rapidly die (peripheral necrosis)without undergoing any preliminary changes (see *Necrosis*). This raising of the periosteum by pus may extend round the circumference of the bone until some closer attachment is met with, such as the linea aspera of the femur, or spread along the bone as far as the epiphysial line, to which the periosteum is firmly attached.

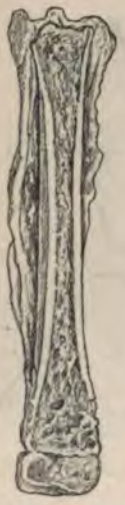


Fig. 118.—Diffuse infective osteomyelitis of the tibia, which was followed by destruction of the knee and ankle joints. (St. Bartholomew's Hospital Museum.)

(*d*) *Subacute and chronic infective periostitis* is caused by pyogenic organisms like the acute form, also by a caseating tubercle, a breaking-down gumma, a typhoid node, or an extension to bone from the soft parts, *e.g.*, by a chronic ulcer of the leg. Besides the symptoms of simple periostitis, there is throbbing with softening of the swelling, which then fluctuates, and is found to contain pus when explored. In chronic cases the pus is thin with only a few fatty pus corpuscles, appearing as a transparent, sticky, synovial-like fluid (*periostitis albuminosa*). The surface of the bone forming the floor of the abscess is roughened by caries, or the outer compact table may be found necrosed. Spreading from the periostitis a general hypertrophic inflammation may affect much of the shaft of the bone, with or without necrosis, the texture becoming spongy, osteoporotic, and yielding under the body weight.

Osteomyelitis.—*Osteomyelitis* is the term for inflammation commencing in the blood-vessels and involving the connective tissue and cells of the *interior* of bone, whether the medullary cavity, cancellous spaces, or Haversian canals.

(*a*) *Simple osteomyelitis*, if *acute*, causes at first softening from the increased vascularity, the bone bleeding freely and yielding more readily than normal to a cutting instrument, and showing evidences of blood extravasation. As a result bending and deformity arise.

If the inflammation is *subacute or chronic* from the first, or becomes so after an acute stage, sclerosis ensues, cancellous bone towards the surface becomes compact by the formation of somewhat irregular Haversian systems, and cancellous or even compact bone encroaches upon or fills up the medullary cavity. *Simple localised* osteomyelitis is commonly the result of an injury, a fracture, separation of an epiphysis or lodgment of a foreign body, such as a bullet. If the line of the epiphysial cartilage is involved growth may be hindered or arrested, and deformity results. *Simple diffuse* osteomyelitis is met with in constitutional affections, such as rickets and osteitis deformans.

(*b*) *Infective osteomyelitis.*—Acute infective osteomyelitis is the result of the growth in the bone of pyogenic organisms, in particular the staphylococcus pyogenes aureus. It tends to spread along the medullary cavity, outwards to the surface, and then to strip up the periosteum, or invade the neighbouring joint, and large portions of the bone may undergo death, *central necrosis.* By means of lymphatic absorption and of septic thrombosis of neighbouring veins, the clot in which breaks down and gives rise to septic embolism, general infection by the staphylococcus follows. The patient suffers from toxinæmia, septicæmia, or pyæmia, and may die of septic pneumonia or of exhaustion.

Infective osteomyelitis may arise by direct infection in the case of a compound fracture or septic wound exposing bone, or may spread up the medullary cavity from a septic amputation wound. More frequently nowadays the infection is hæmatogenous in origin. The organisms arrive in the blood-stream and settle down where the bone is specially vascular, viz., at the growing ends of the diaphyses of the long bones (Fig. 117). Here there are large capillary loops wherein the stream is slow, and which a slight injury, a strain, blow or fall may easily rupture and cause extravasation of blood, a favourable nidus for the organisms. A previous disease, measles, scarlet fever, etc., may have weakened the resistance of the patient, or a distant focus of suppuration and necrosis such as chronic ear disease, tonsillitis, carious teeth, sores in the mouth, may be the source of the organisms. Wet and cold may favour an attack by inducing congestion. Often the disease occurs without warning in previously healthy boys and girls, more frequently and more acutely in the former than in the latter.

Localised osteomyelitis. Abscess (Fig. 119).—The staphylococci develop an acute abscess as in soft parts, the leucocytes rapidly absorbing the cancellous septa, or causing them to die, so that in the abscess cavity are débris of septa or a distinct sequestrum of necrosed bone (Fig. 120). Supposing the septic inflammation to remain confined to the cancellous bone around it, there takes place a simple inflammation ending in sclerosis. By this means the abscess cavity becomes enclosed in a wall of compact bone, which shuts it off from the medullary cavity. The simple inflammation extending to the

periosteum causes new periosteal bone to be formed on the surface, so that the shaft appears to be enlarged in a spindle-shaped fashion. The pus may gradually become more fluid with fatty degeneration of the pus cells, and the sequestrum becomes loose, and of a dark colour, or it may be partly or wholly removed by phagocytosis.

Central suppurative osteomyelitis and necrosis.—The pus extends into the central medullary cavity and partly or wholly involves it. The inner layers of cancellous bone become necrosed and form an irregular tube of dead bone, or, if in an amputation stump, the sequestrum is conical, involving at the lower end a thick ring of bone and tapering upwards. If the septic inflammation remains limited to the medullary cavity and the neighbouring cancellous bone, simple sclerosing inflammation takes place in the periosteum,

FIG. 119.—Abscess in end of tibia. The so-called pyogenic membrane is well seen. (From St. Bartholomew's Hospital Museum.)

FIG. 120. — Necrosed cancellous bone in abscess cavity. (From St. Bartholomew's Hospital Museum.)

and new compact bone is formed on the surface of the old, causing all the shaft of the bone to appear thickened.

Suppurative periostitis and necrosis of the whole thickness of the shaft.—The pus breaks through from the end of the diaphysis and causes acute suppurative periostitis, with or without hæmorrhages in the osteogenetic layers of the periosteum. It may extend so as to separate the periosteum from the whole of the diaphysis, which then dies *en masse* (Fig. 122) and separates at the epiphyses from the ends of the bone, or this extension of the suppuration may be limited by the lines of attachment of tendons or fibrous septa. At the same time the osteogenetic layer of the periosteum may be in part or throughout the whole of its extent destroyed, so as to be unable to form new bone. If, however, the pus is let out, and the dead bone removed at an early date, the whole of the shaft may be restored by the periosteal bone formation, in a young child in a very complete manner. Supposing,

however, the pus only to escape through the soft parts, the periosteum forms an enclosing shell of irregularly compact or spongy bone (Fig. 122), the bone being thickened and perforated by sinuses discharging foul pus, hence called cloacæ, whilst the dead bone lies loose in an abscess cavity occupying more or less of the place of the shaft of the former bone (see *Necrosis*).

Suppurative epiphysitis with arthritis.—This is the more

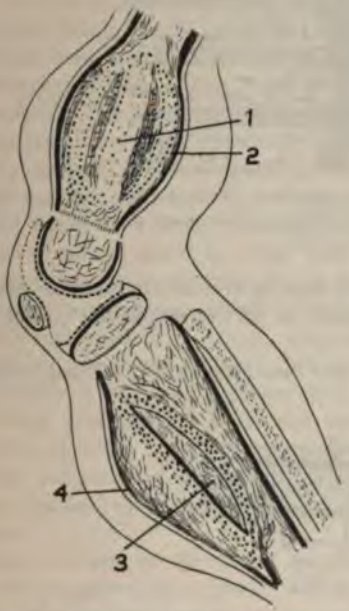


FIG. 121.—Necrosis. Diagram of the femur with central necrosis, and of the tibia with periosteal necrosis. (1) Sequestrum formed in the lower parts of the diaphysis of the femur surrounded by pus and enclosed by (2) an involucrum of new periosteal bone. (3) Sequestrum formed by the outer layers of the shaft of the tibia, covered by (4) periosteal new bone.

FIG. 122. — Necrosis of shaft of tibia, the result of acute infective osteomyelitis. (Druitt's Surgery.)

likely to happen when the epiphysial line is in close connection with the joint-cavity, therefore it occurs more readily in the upper end of the femur than at the lower end. The suppuration extends to and destroys the osteogenetic cells of the epiphyseal line, and the result is an arrest of growth ; or the septic inflammation spreads through the end of the bone to the joint, causing septic arthritis. The centre of the epiphysis, or the whole end of the bone, may become a sequestrum.

Necrosis of bone is due to a rapid and complete thrombosis of the blood-vessels, both arteries and veins, by infective inflammation,

whether entering by the arteries of the periosteum or by the central artery or arteries of the bone. As a result, there may be a superficial, partial, or *peripheral necrosis* of compact bone, a deep *central*

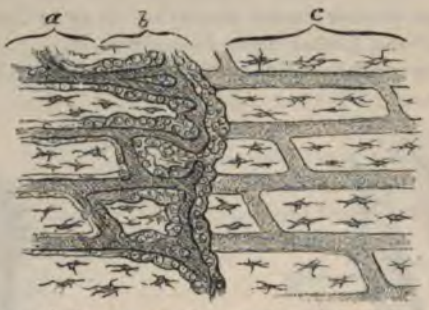


FIG. 123.—Diagram of the process of separation of dead bone. *c*. Dead bone; *b*. Inflamed living bone with formation of granulation-tissue where it is in contact with the dead part; *a*. Healthy living bone.

necrosis involving cancellous bone near or around the marrow cavity, or *total necrosis* of the whole shaft, or of the epiphysial end of the bone.

Characters and separation of dead bone (Fig. 125).—The dead bone

FIG. 124.

FIG. 125.

FIG. 126.

FIGS. 124, 125, and 126 illustrate the formation of a sequestrum, its separation from the living bone, and the cavity left after its removal. *a*. Dead bone; *b*. Living bone; *c*. The separated periosteum lined by granulations; *d*. Cloacæ lined by granulations, which are indicated by shading, and are continuous with those lining the cavity containing the sequestrum; *e*. New periosteal bone perforated by cloacæ. *f*. Cavity left after removal of the dead bone. (After Billroth.)

is at first white, but becomes brown or black when exposed to the air and decomposing discharges. Compact bone when dead is smooth, and rings when tapped by a metal sound or probe; cancellous bone or compact bone if partly eroded by phagocytosis, is rough

and uneven, with jagged edges, and grates on touching with a probe. When a portion of bone has become dead it is separated by the activity of the living cells or osteoclasts derived from pre-existing cells and leucocytes which arrange themselves on it and eat into it or erode it so as to reduce its size. Also, they absorb the still living septa immediately around, and so increase the cavity in which the sequestrum lies. In peripheral necrosis, affecting a limited area of the external compact layer of bone, *e.g.*, of the skull (see Fig. 138), a groove forms like the line of demarcation between the dead and living in soft parts, and deepening and extending beneath the dead bone the latter is cut off and rendered loose, so that it may spontaneously come away, "exfoliate," as it is termed, or be easily extracted. The cavity left is lined with vascular granulation tissue, the superficial layers of which become pus cells, and the deeper layers, consisting of osteogenetic fibroblasts, form new bone to fill up the cavity. Where the periosteum is not destroyed, new bone is formed by it, as well as by osteoblasts in the outer layers of bone around a central necrosis. The new bone is thus said to invaginate the dead bone or sequestrum by an involucrum, in which the sequestrum comes to lie loose (Figs. 124, 125, 126).

The sequestrum, if small, may be gradually absorbed in the course of weeks, or, if large, remain until removed by operation. The cavity is lined with granulation tissue, composed of leucocytes becoming pus cells. In recent cases the granulations are very vascular, in older cases the lining is smooth, velvety, less vascular, looking like mucous membrane. Through the involucrum the cavity communicates with the surface by one or more openings, termed cloacæ.

Quiet necrosis is the term employed for the process when no external suppuration ensues. The sequestrum comes to be surrounded by an involucrum of compact bone, which, being composed of new periosteal bone, causes an external enlargement of the bone and simulates the growth of a tumour. In the cavity the sequestrum may disappear, leaving a thin oily fluid, where also pyogenic organisms in a resting state remain alive and potentially active for many years.

Phosphorus necrosis (see *Diseases of the Jaws*).

(*c*) *Subacute and chronic infective osteomyelitis* is produced by tuberculosis, syphilis, typhoid fever, and pyogenic processes running a slow course. In the most chronic non-suppurative variety, the chief result is sclerosis, formation of compact cancellous bone to excess around the inflammatory area. The bone becomes heavier and tends to bend. Or a *chronic abscess* forms at the focus of inflammation, especially in the cancellous tissue of the ends of the long bones. The wall of the cavity is surrounded by sclerosed bone, or it becomes gradually absorbed, so that the pus eventually bursts into the soft parts, or is discharged into a joint, or a spontaneous fracture occurs.

Caries or *ulceration* (Fig. 128) of bone is comparable to chronic ulceration in soft parts, and is a process of rapid lacunar absorption; septa are first softened, then absorbed or detached by means of leucocytes and osteoclasts. Compact bone becomes cancellous, rough, worm-eaten; cancellous bone disappears leaving a cavity. When masses of cancellous bone are detached and found loose in the pus the condition is known as *caries necrotica*.

Signs of acute osteomyelitis.—Acute septic osteomyelitis often commences suddenly as a severe inflammatory fever, with rigors and delirium; in the milder types it is a toxinæmia, due to the absorption of toxins; but is a septicæmia, staphylococci being found in the blood, in the more severe.

Fig. 127.—Subacute osteomyelitis, also called rarefying osteitis or caries. The Haversian canals and canaliculi disappear and compact bone becomes cancellous; the septa of cancellous bone disappear.

Locally there is deep-seated pain, dull in character, or intense, becoming almost agonising on the least attempt at handling. The soft parts covering the bone become swollen from œdema, causing the skin to appear white and waxy, then, as the deep-seated suppuration raises the periosteum or spreads outwards into the soft parts, dusky red. Indistinct fluctuation, or merely a tense elasticity, may now be obtained, whilst the limb below becomes œdematous. The inflammatory swelling is situated around the seat of injury if directly inoculated, about the end of the long bones (Figs. 117 and 121) if hæmatogenous in origin, or in special positions if it extends to other parts, as in the case of the ear to the temporal bone, from the nose to the upper jaw, from the mouth to the lower jaw. When of hæmatogenous origin the commonest situation is the lower end of the femur or upper end of the tibia. There the swelling can be clearly distinguished in its early stages (compare Fig. 117 with Fig. 129) from an infection of the knee, for the ends of the diaphyses are well beyond the joint, and the joint is superficial. In other cases the end of the diaphysis is more closely in relation to the joints, or the joints are more obscured by soft parts. Hence, in the case of the upper end of the femur, or the upper end of the humerus and other ends of the long bones, it is difficult to distinguish from arthritis, and even if the inflammation commences in the diaphysis, it quickly involves the joint in such cases. As regards *differential diagnosis*, acute septic osteomyelitis is most likely to be confounded with acute rheumatism. The special signs of rheumatic fever, the multiple affections of the joints, and of the heart, the examination of the serous fluid aspirated from the joints,

the relief of the pain by salicylates, should serve to exclude rheumatism. On the other hand, septic osteomyelitis may be traced to some source of septic infection, or if hæmatogenous commences at one place, other bones and joints being free and not swollen, although the patient may be generally tender to the touch. The patient assumes quickly the pale, earthy look of septic infection, and may be slightly jaundiced, or develop a septic rash. The blood will show leucocytosis and may yield staphylococci, the swelling when aspirated containing pus with staphylococci. The later general infection, pleurisy, pneumonia, endocarditis, and pericarditis, the development of pyæmic abscesses in joints or soft parts, are all attended by the development of the general state of septic intoxication, called the typhoid state.

Treatment.—It is, unfortunately, far too often the case that a hasty preliminary diagnosis of acute rheumatism stops the way to surgical treatment until grave or fatal injury has taken place. The disease is one entirely for surgical measures.

FIG. 128.—Diagram of caries. A. Granulation tissue surrounding capillary loops; B. Small-cell exudation destroying the bone; C. Small-cell exudation between vessels and walls of the Haversian canals; D. Normal bone.

An incision must be made into the swelling in the line of the bone, avoiding large blood-vessels and nerves, and without entering the neighbouring joint. The pus may be reached on dividing the periosteum; the incision should then be extended along the bone as far as the periosteum has been raised. The pus and blood may be seen coming from the softened diaphysis, when, by means of a trephine, gouge, or spoon the centre of the end of the diaphysis should be reached. In an early case one should avoid opening the general medullary cavity, or injuring the epiphysis or the joint. When, however, the pus has already spread into the central canal, a groove must be cut along the shaft of the bone with an angular gouge, etc. Having exposed the full extent of the suppuration, all blood and pus is removed from beneath the periosteum, also broken-down marrow and pus from the central canal, afterwards wiping out the infected area with carbolic acid, 1 in 20, or perchloride of mercury, 1 in 1,000, all the antiseptic being forthwith swilled away; then the cavity is dressed by placing iodoform gauze strips in contact with the bare bone, in the hope that necrosis will not ensue, or only do so to a limited extent. This treatment should be followed by relief of the signs of septic intoxication. The bone cavity should be found dry on changing the dressing. Vascular

granulations spring up over the bare bone, and the cavity is slowly filled up.

If, unfortunately, the surgical treatment is commenced at a later stage, the whole diaphysis may be found already necrosed, and should then be removed, leaving the epiphyses and their cartilage, the cavity being filled with gauze. If the osteogenetic layer of the periosteum has not been destroyed, and the patient is young and previously healthy, the whole diaphysis may be restored. The limb, when part of the shaft or the whole has been removed, must be placed on a splint, and extension may be required. If the septic inflammation has already spread to the epiphysis and joint, as in the case of the hip or shoulder, the end of the bone requires to be excised and the joint treated as in *Septic Arthritis.*

If extension has occurred to the soft parts, but only to a limited extent, the suppurating tracts should be freely laid open, wiped out with an antiseptic, and stuffed with gauze. This is a much better measure than making a counter-opening and inserting a drainage tube.

If the vein in the neighbourhood, *e.g.*, the superficial femoral in the case of the lower end of the femur, the axillary in the case of the shoulder, be blocked, as indicated by œdema and venous obstruction of the limb below, it may be possible by ligature or by excising a length to save the patient from septicæmia and pyæmia. Thrombosis of the neighbouring vein or veins is quickly followed by breaking down of the clot, then by severe rigors which mark the onset of pyæmia. This event, also diffuse suppuration in the soft parts, also the rapid exhaustion of the patient as shown by a pulse-rate rising above 120 per minute, indicate the necessity of immediate amputation to save life. The general treatment of the patient is described on p. 53.

The *signs of subacute and chronic osteomyelitis* are a dull, aching pain attended by œdema and swelling, and later by thickening of the bone. An abscess may slowly appear, become superficial and burst, forming one or more sinuses leading down to bare bone. If the disease remains confined to the bone, local heat and tenderness on pressure, with thickening, point to the formation of a bone abscess; the bone may bend, or the epiphysis being involved growth may be increased so that the limb is longer, or growth is checked or arrested so that the limb is found shorter, or is one-sided, irregular, so that a deformity such as knock-knee arises. The swelling begins near the end of a bone, from which it may extend along the shaft to cause general thickening, or ultimately burst into a joint and cause septic arthritis, or a spontaneous fracture arises. Remaining untreated, extensive necrosis ensues, the patient suffers from prolonged septic absorption, develops metastatic abscesses or amyloid disease, or the disease spreads to the neighbouring artery, *e.g.*, the popliteal, giving rise to an aneurysm and hæmorrhage. Epithelioma may develop at the

mouth of a discharging sinus of long standing, and spread backwards into the bone, which it infiltrates, and gives rise to fracture ; or sarcoma may arise in the bone itself.

The *diagnosis* is made by noting the commencement of the disease near the end of the shaft of a bone as distinct from a joint, or as following on some injury or by extension, *e.g.*, from the ear or mouth or nose. Evidence may be found of general infection by tubercle, syphilis, typhoid fever. The disease may be at first taken for a sarcoma. Antisyphilitic treatment may be adopted in the first place, but even although the disease may have been started by syphilis, secondary pyogenic infection may have followed and set up necrosis. Moreover a gumma may resist treatment. An examination with the *x* rays may be of service. Compare skiagrams, pp. 312 and 362.

In all doubtful cases an exploratory incision is required. It is very wrong to delay and call the swelling "rheumatic." The incision is made down to the bone, and the periosteum being found greatly thickened, a piece should be excised and quickly examined microscopically. Inflammatory tissue should present a uniformly fibrous appearance with œdema and small abscesses, a gumma small yellow points undergoing mucoid softening, a sarcoma no suppuration (unless it has followed as a sequela), but a vascular tissue with hæmorrhages. An outer shell of newly-formed periosteal bone being reached, this may be first bored into by an awl, then cut through with gouges or the trephine. A cavity is exposed lined with vascular granulation tissue containing a sequestrum, unless this has been absorbed. The cavity within the involucrum must be laid open to its full extent by cutting away the shaft for not more than a quarter to one-third of the circumference. A long channel may have to be cut through much of the length of the diaphysis, *e.g.*, of the femur or humerus, the cavity and all sinuses well scraped out, organisms destroyed by an antiseptic, and a gauze dressing applied and changed frequently until the cavity fills up with healthy granulations in the depths of which new bone is formed. The filling up of the cavity may be aided by bone-grafting.

Amputation is rendered necessary when the patient is already exhausted by long-standing disease and by age, so that his power of repair is feeble, and amyloid disease is commencing. It is also required when spontaneous fracture or ulceration into the main artery with hæmorrhage has taken place, when an epithelioma has grown in from the mouth of a sinus, when a vascular new growth around the focus of suppuration indicates a sarcoma, or when there is extension to the joint, or a wide involvement of soft parts.

Bone repair—Bone-grafting.—The osteogenetic activity of the periosteum has been excited by plugs soaked in chloride of zinc, 5 to 10 per cent., or in turpentine. Pieces of the periosteum and bone of animals have been grafted in. However, there is no sufficient evidence that living periosteum and bone can be grafted in so that the graft

itself persists and the cells in it actually form bone; it is supposed rather, that when inserted free from germs, the graft forms a favourable scaffolding which is invaded by osteogenetic cells from the healthy neighbouring marrow and periosteum, producing new bone whilst absorbing the graft. Hence there appears no necessity to make use of grafts from a recently-killed animal, certainly not of a living one; and bone removed from the same patient, or taken from another, *e.g.*, undergoing amputation, appears to offer no special advantage. Handy aseptic materials of proved service are: (i.) decalcified bone in chips—sections of healthy ox bone decalcified and preserved under absolute alcohol until required; (ii.) calcined bone in chips or powder heated afresh immediately before use in an iron spoon over a flame; and (iii.) plaster of Paris mixed with 1 in 20 carbolic acid to the consistency of a thick cream. Dead bone is removed, the surrounding bone scraped and gouged until vascular, healthy bone is reached, all crannies are well sponged out with an antiseptic and the cavity is dried. Then the material is rammed in level with the surface and a gauze dressing applied above.

Bone flaps for special cases, such as the skull or nose, are composed of skin, periosteum and bone raised by the chisel and shifted over the gap.

Inflammation of Joints.

General anatomy.—The union of separate bones, *synarthrosis*, either by fibrous tissue, *syndesmosis*, or by cartilage, *synchondrosis*, may in later life become osseous, *synostosis*. The formation of a fissure between the ends of separate bones, a *diarthrosis*, may be only partial, as in the pelvis. In a complete joint or diarthrosis the ends of the bone are covered by articular cartilage in place of the periosteum which covers the rest of the bone. The external covering or capsule of the joint consists of a vascular synovial membrane secreting synovial fluid, outside which is connective tissue and fat in places pushing the synovial membrane into the interior of the joint as folds and villous processes. In some joints inter-articular fibro-cartilages consisting of fibrous and elastic tissues containing cells are interposed between the joint surfaces.

The *synovial membrane* consists of a superficial layer having many connective-tissue cells arranged rather irregularly in layers, parallel to the surface, without any basement membrane or other line of demarcation from the innermost layer of indistinctly marked endothelial cells lining the joint. The deeper layers are of connective tissue with few cells. It is a very vascular tissue, branches of articular vessels running to the synovial surface and forming tortuous loops. Fat cells, also in places cartilage cells, but no gland cells, exist. The synovial membrane is attached to the bone round the joint at the junction of the articular cartilages with the periosteum.

The *articular cartilage* is, on the other hand, non-vascular,

although its edge may be overlapped by synovial folds which, when inflamed, become exaggerated. It is composed of hyalin cartilage, several rows of cells lying in strata parallel to the surface without any endothelial covering, the deeper layers in contact with the cancellous bone showing calcification.

Degeneration of articular cartilage.—Articular cartilage only degenerates. As a non-vascular structure it does not become inflamed, but plays a passive part, either disappearing molecularly or dying *en masse* before advancing inflammation; neither do the cartilage cells proliferate to form new cartilage or bone.

In *fibrillation of cartilage* the hyalin substance disappears leaving visible the fibrillæ, which are no longer cemented together with the hyalin matrix, so that the cartilage has a finely striated or granular appearance, varying according to the direction in which the fibres are cut in the section examined. The cartilage cells partly undergo fatty degeneration and are destroyed, partly multiply and fall out through holes on the surface. Thus the cartilaginous surface becomes irregular and shaggy, and very thin. As the falling out of the cells and the disappearance of the hyalin substance causes the cartilage to become thin, there is a communication with the vessels of the bone. Vascular bone tissue may now replace the cartilage, and form densely compact ivory bone or be partly worn away. In the neighbourhood of the junction of the cartilage with the vascular periosteum and synovial membrane there is a special tendency for new bone to form in excess (*osteophytes*) (see further under *Arthritis*).

Synovitis.—*Synovitis* implies an inflammation commencing in and mainly confined to the synovial membrane, the tortuous capillaries near the surface of which tend to render the blood stream slow. Hence passive exudations readily occur, or the vessels become thrombosed by germs which arriving in the blood stream are easily arrested there. The thin walls are prone to rupture, so that blood infiltrates the membrane, or becomes extravasated into the joint.

Simple synovitis.—(*a*) *Hydrarthrosis*, or simple pathological exudation or transudation, consists chiefly of synovial fluid of a clear straw colour, containing mucin, with only a small amount of fibrinogen, hence very few shreds of fibrin and scarcely any leucocytes. The effusion is of a passive character, with very little signs of inflammation, and occurs in feeble patients of all kinds—anæmic women with menstrual trouble, old people from nervous disturbances, exhausting affections such as dysentery, etc., also in young people as an insidious type of tuberculosis.

(*b*) In *acute synovitis* there is much more fibrinogen exuded, which coagulates to form fibrin, partly infiltrating the swollen synovial membrane, partly covering its surface, or forming more or less detached masses in the joint. The membrane is swollen, bright red, and bleeds freely. Simple acute synovitis is commonly the result of injury, a sprain, blow, etc., and is accompanied by a

variable amount of blood extravasation. Another common cause is acute rheumatic fever.

(c) *Subacute* and *chronic synovitis* are set up by gout, syphilis, etc., also by gonorrhœa and tuberculosis when these affections are early and limited.

In synovitis (Fig. 129) the joint is swollen from the distension of its capsule, tender and painful, and is held in the position in which the capsule can be most relaxed. In superficial joints and acute inflammation the skin is red. Even when the degree of inflammation is very slight, the normally cold skin over the patella in the case of the knee, or over the olecranon in the case of the elbow, feels hot when the palm is applied.

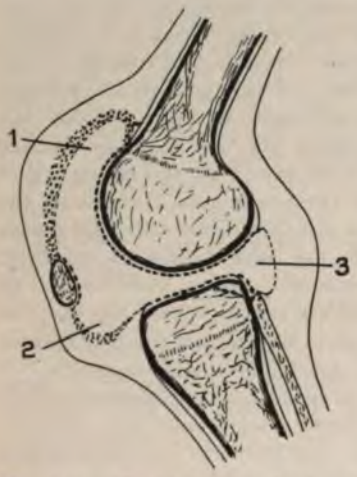


FIG. 129.—Synovitis. The collection of fluid may distend the synovial membrane in the case of the knee-joint.
1. Beneath the quadriceps extensor;
2. Below and to one side of the patella;
3. Towards the popliteal space.

In simple traumatic synovitis the inflammation subsides; should blood-clot become changed into loose bodies troublesome subacute and chronic synovitis follows until these are removed.

Acute rheumatic synovitis may disappear entirely by resolution, leaving no ill effect. A less frequent form of rheumatism goes on to replace the cartilages from the periphery inwards by fibrous tissue, which thus limits movement and unites the adjacent surfaces, and so results in ankylosis.

Chronic hydrarthrosis, or hydrops articuli, may persist for a long time, causing the joint to remain weak, with slight heat. If tuberculous, destruction of the joint ultimately ensues. In chronic so-called rheumatic diseases, the synovial membrane gradually increases in thickness, and develops hypertrophy of its fringes. In other cases, the pouches in connection with joints are distended, or an extension takes place to the normal bursæ near a joint, or protrusions of the synovial membrane occur between the fibres of the capsule, owing to the increased tension. These also bulge outwards between muscles to form cysts (Morrant Baker's cysts).

Treatment of simple synovitis.—The joint must be kept at rest, especially in the case of the lower extremity; a splint and even extension may be required to resist the onset of a deformity. The heat is relieved by an ice-bag, Leiter's tubes, or an evaporating lotion. In very acute cases, leeches, half a dozen at different points, may

be applied over the joint, and further bleeding favoured by hot fomentations. Fresh extract of belladonna, with equal parts of glycerine, or boric-acid fomentations on which a teaspoonful of tincture of opium is sprinkled, will best relieve pain. Whenever there is much fluid the joint should be emptied by aspirating, taking special antiseptic precautions, and the fluid then examined. When the inflammation has become subacute, counter-irritation is useful. Blisters are applied, several of the size of a shilling, over the joint, or the surface is painted every other day with iodine liniment until the skin becomes like brown parchment. Unguentum hydrargyri compositum (Scott's dressing) may be spread on chamois leather or lint cut into strips and applied over the joint.

Until inflammation has subsided rest is required, lest any movement tend to set up recurrent inflammation. But as soon as possible gentle movements should be commenced, aided by shampooing with hot water and massage limited to what the patient can bear without pain.

If fluid persists in spite of rest and strapping, ʒj to ʒii of tincture of iodine preceded by a little cocain may be injected after drawing off the fluid. Or the joint may be washed out with boiled water under an anæsthetic, either through a cannula inserted by means of a trocar or through a small incision whenever the presence of lumps of fibrin and loose bodies are anticipated.

When there is *chronic thickening of the synovial* membrane as the result of a markedly fibrinous inflammation, with which the synovial membrane is infiltrated and masses of fibrin adhere to the inner surface, tuberculosis is the common cause, but it may follow from chronic rheumatism, syphilis, gonorrhœa, etc. If not arrested and reduced by mercury ointment, the thickened masses should be excised (arthrectomy).

Cysts are excised with ligature of the pedicle (see p. 374).

Chronic arthritis—Arthritis deformans.—The changes that occur are two-fold. At the margin of the joint, at the junction between the periosteum and the synovial membrane with the articular cartilage, there is an increased bone formation. Sclerosis takes place, so that cancellous bone becomes compact, also irregular masses of dense bone form. Osteophytes, nodules, ridges or lipping, cause the end of the bone to be no longer rounded inwards towards the joint, but everted. In extreme cases there are irregular bosses and masses, mainly of hard bone, resembling exostoses, either covered with cartilage or merely fibrous tissue derived from the periosteum, which deform the joint and hinder movement (Fig. 130). The other change is in its slighter form a fibrillation of cartilage (see p. 325) which is worn away, and beneath it the cancellous bone is exposed. The bone may in its turn wear away in parallel grooves corresponding to the movements of the joint, and thus much of the end of the bone may be absent, so that the surface becomes flat, and this, with the eversion of the edges, give the end of the bone a mushroom shape.

bony, *fibrous* and *bony ankylosis* or *synostosis* (see p. 333). Around the ends of the bone the periosteum tends to form irregular masses of bony osteophytes. The result may be a useful limb if in good position; if the joint surfaces are allowed to become displaced there is developed a serious deformity which may have to be rectified later. The muscles around a diseased joint waste; this they do partly from disuse, but also partly as the result of the septic inflammation which appears to promote atrophy and fatty degeneration. Thus the joint comes to form the middle of a spindle-shaped swelling, owing to the atrophy of the muscles above and below it.

The *treatment* of acute suppurative arthritis is immediate incision. This cannot be done too early; the result of an incision during the stage of acute swelling, before much pus has formed, may be followed by a return almost or completely to the normal, the destructive process being cut short. Thus in a pyæmic joint incised as soon as the oily fluid has begun to collect, recovery with a freely moveable joint is probable. In doubtful cases some fluid should be drawn off with an exploring syringe and examined microscopically for pus cells and organisms.

A suppurating joint should be incised freely, washed out, wiped out with an antiseptic, and a drainage-tube inserted, or a plug of iodoform gauze. In some cases, *e.g.*, when pus has burrowed outside a joint, a counter-opening may be made, a drain passed, and a constant stream of warm boric acid or Condy's fluid allowed to drip through.

An effective method of treating an acutely suppurating joint, after clearing its interior, is to fill it and any pockets with iodoform gauze. After a few days, healthy granulations may line the cavity, then a secondary suture can be used, and union by second intention without further suppuration obtained. Sometimes, when there is much inflammatory infiltration around a joint, immersion in a boric acid bath gives the best results. A careful watch must be kept up for extensions tracking up among the muscles, requiring further treatment. Amputation is called for to save life when the patient is sinking under septic absorption and exhaustion.

Chronic suppurative arthritis is either a tuberculous process, or one very similar as regards course and treatment.

Loose bodies in a joint may be formed in several ways, of which the following are the chief:—1, by the proliferation of the cartilage cells that normally exist in the synovial fringes, and the subsequent detachment of the little mass of cartilage so formed through the rupture of its peduncle in the movements of the joint (Fig. 134); 2, by thickening or hypertrophy of a synovial fringe, or by extravasation of blood and subsequent organisation of the fibrinous coagulum in a synovial fringe, detachment occurring in a manner similar to that in the former case; 3, by necrosis of a portion of the articular cartilage or bone; 4, by chipping off of a portion of the articular

or inter-articular cartilage during some injury to the joint; 5, by the separation of an osteophyte, as in osteo-arthritis. Loose cartilages are most common in the knee, but may be met with in any joint. They are generally single, but may be multiple, and vary in size from a pea to a walnut.

Symptoms.—The chief symptoms are pain and momentary locking of the joint, due to the loose body slipping between the articular surfaces. In the knee this occurs during flexion, and on the patient attempting to straighten the joint the loose body, by forcing the articular surfaces apart, stretches the ligaments, and thus gives rise to a sudden and excruciating pain, perhaps so severe as to cause him to fall. The joint does not remain locked as in the displacement of a semilunar cartilage, since the loose body, after being gripped between the articular surfaces, slips back into the synovial cavity. These attacks of pain and locking occur at varying intervals, and are generally followed by subacute synovitis for a few days. On examination the body may often be felt somewhere in the synovial pouch, probably on the outer side of the joint in the case of the knee. If attached, its movements will be limited, but if free it can frequently be made to move round to the opposite side of the joint. It may perhaps disappear by passing into some of the synovial recesses, though it can generally be felt again on moving the joint. At times in the knee the loose body may become wedged in the inter-condyloid notch in front of the crucial ligaments, the patient being then unable to straighten his limb. The presence of the loose body may be demonstrated by the *x* rays (Plate II.).

FIG. 134.—The formation of a loose cartilage in a joint. A little mass of cartilage attached by a slender stalk. (St. Bartholomew's Hospital Museum.)

Treatment.—If the loose body gives rise to little or no trouble, and can be easily fixed by a pad and bandage or knee-cap, it should not be interfered with; nor should any operation, as a rule, be undertaken where the joint is disorganised by osteo-arthritis, but arthrectomy may be performed where the synovial membrane is studded with masses of cartilage. Under other circumstances the loose body should be removed by transfixing it with an aseptic strong needle on a handle thrust through the skin, so that the loose body may not slip away or be lost during the operation, and then cutting down on the capsule, and when all bleeding has been stopped, opening the joint. The body, if loose, will generally slip through the opening; if attached, its pedicle must be ligatured and

PLATE II.

ram of a loose cartilage (partially ossified) in the knee-joint. (Taken by Dr. Hugh Walsham.)

[*To face p.* 332.

divided. The operation should be performed with the strictest antiseptic precautions, and the patient prepared by a few days' rest in bed in the case of the knee with his joint on a splint. The wound may be safely closed without any drain. The splint should be continued after the operation, or the joint placed in a plaster-of-Paris bandage till the wound has healed and all fear of inflammation has passed. In a case in which a loose body was wedged in the inter-condyloid fossa, Walsham removed it by laying the joint freely open through an incision across the patella.

Ankylosis or stiff joint may be intrinsic, a fibrous or bony union of opposing joint surfaces; or extrinsic, due to the spasm or contracture of surrounding muscles or of cicatrices following burns, but then is often combined with shortening of ligaments and partial adhesions between the joint surfaces.

Fibrous ankylosis, also called ligamentous, or by some authors, false, in contradistinction to the bony, which they then term true, is the union more or less complete of the articular surfaces of the joint by fibrous tissue. Thus it may consist of—1, a mere thickening of the capsule; 2, a thickening and shortening of the ligaments; 3, the formation of fibrous bands within the joint; 4, the partial removal of the cartilages and the union of the bones by fibrous tissue; and 5, the above conditions variously combined. It may be the result of joint-disease, or of keeping an inflamed joint for too long in a state of rest. Sometimes it may terminate in bony ankylosis.

FIG. 135.—Bony ankylosis of the hip. (St. Bartholomew's Hospital Museum.)

Bony ankylosis is the firm union of the articular ends of the joint by bone. It is often a further stage of the fibrous variety. The articular surfaces may be united evenly and uniformly, or by irregular bridges of bone, or partly by bone and partly by fibrous tissue. The union may occur with the articular surfaces in contact in either the extended or the flexed position, or at an angle between the two (Fig. 135); or it may occur with the articular surfaces dislocated from each other. This is the way in which bony ankylosis usually follows on suppuration, especially when the result of tuberculous disease or injury. But suppuration when due to pyæmia may not end in ankylosis; indeed, complete movement may be obtained if the treatment be early enough. Bony ankylosis occurs without suppuration after tuberculous disease in young people, *e.g.*, in the atlas or axis, after rheumatism, arthritis deformans, Charcot's disease, gout, gonorrhœal rheumatism. It has occasionally happened after

a simple injury, also after nerve division and from long retention in a deformed position, as the spine in lateral curvature.

The *signs* of ankylosis are obvious—*i.e.*, the joint is stiff. It only remains to diagnose the fibrous from the bony. In the former there is slight movement, and generally pain; in the latter neither movement nor pain. In some instances, however, as in ankylosis of the shoulder and hip, the joint may be held so firmly by the contraction of the muscles that the fibrous may simulate the bony form; and again, although bony ankylosis may exist, the revolving of the scapula or pelvis, as the case may be, on the trunk may make it appear that there is some movement in the affected joint. A skiagraph or an examination under an anæsthetic will settle the point.

The *treatment* will vary with the nature of the ankylosis. In the spurious form something may often be done by dividing the cicatrices, or by freeing the parts by a plastic operation, though in such cases the treatment is seldom very hopeful. *In the fibrous form* an attempt should be made to restore the natural movements of the joint—1, by manipulation, friction, and passive movements, dry heat and electrical applications; 2, by gradual extension, employing a weight and pulley, or some form of cog-wheel or screw apparatus; 3, by forcibly breaking down adhesions under an anæsthetic after tenotomy of any contracted tendons, but this should not be done in tuberculous disease; 4, by incision of the joint, division of the adhesions combined with open tenotomy and syndesmotomy of contracted tendons and fascia, followed by slow extension if the contracture does not yield readily.

Bony ankylosis with the limb in a good position is often the best result obtainable. To certify a faulty bony ankylosis, either a wedge-shaped excision or osteotomy has to be done.

Functional rigidity of a joint.—Hysterical or neuromimetic muscular spasm may hold a joint so fixed as to simulate ankylosis. This may be seen in young adults following a slight injury; the joint is not hotter than normal, or swollen, and moves freely under an anæsthetic, after which the patient recovers full use. In young women especially there may be neuralgic pain in a joint, unassociated with other signs of inflammation, and the pain is not increased on movement, especially if the patient's attention is distracted. Redness over the joint may have been caused by friction or some irritant, arnica tincture, a popular remedy, sometimes producing much superficial redness. Slight adhesions or synovitis, *e.g.*, after injury, may occasion the rigidity. Before moving the joint freely, tuberculosis must be excluded.

Treatment.—After free movement under an anæsthetic, active exercise of the joint must be insisted on; also massage and shampooing are of use.

SPECIAL VARIETIES OF INFLAMMATION OF BONES AND JOINTS.

Pyogenic inflammation.—*Staphylococcus pyogenes aureus* (see p. 60), is the chief cause of acute purulent inflammation in bones and joints, especially when hæmatogenous in origin, *i.e.*, reaching the focus of inflammation by the blood-stream. It also plays an important part in secondary suppuration, supervening in tubercle, variola, syphilis, gonorrhœa, typhoid fever, and is the chief source of pyæmia (p. 53). Characteristically the hæmatogenous inflammation commences in the cancellous tissue of the end of the diaphysis favoured by the vascularity of growing bone, especially in boys approaching puberty. Sometimes a blow seems to start the mischief, presumably by causing a slight hæmorrhage, in which the organisms can begin to develop. For instance, in a very acute case rapidly fatal by pyæmia in a boy of twelve after a blow on the knee, an ecchymosis, the size of half a crown, was found over the inner condyle of the femur on the joint surface. The entrance of the organisms is often quite unknown, *i.e.*, the infection is cryptogenetic. In other cases slight lesions, such as a carious tooth, chronic tonsillitis, nasal necrosis, intestinal or rectal ulceration or a scratch have offered a possible mode of entry. The pus in such lesions generally yields a pure cultivation of staphylococci, so also in extensive osteomyelitis, or periostitis, or arthritis. In the blood if septicæmia follows, and in metastatic pyæmic abscesses there may be found only staphylococci. Osteomyelitis accompanied by bending and the formation of a sequestrum, quiet necrosis or necrosis without suppuration, has the same organisms as a cause, for staphylococci can be cultivated from the fluid. Moreover, in old-standing cavities in bone, which have had no communication with the exterior for fifteen to twenty-five years, staphylococci have been found.

Whilst staphylococci generally cause purulent inflammation, the inflammation set up by staphylococci may occasionally remain simple, and is then often called "rheumatic," being due presumably to the effect of the toxins only.

Streptococcus pyogenes does not often act as the sole cause of septic inflammation of bones and joints, but is generally mixed with staphylococci, especially after fevers, scarlet and puerperal fever, measles, diphtheria, smallpox, and otitis media. As an unmixed infection it may be inoculated through a septic wound, acute tonsillitis, etc. In such cases a rapidly progressive destructive arthritis is set up with œdematous infiltration, going on to suppuration in the soft parts around, rapid septicæmia with endocarditis or pleurisy. In the rare cases of pure infection, anti-streptococcic serum not only is of the greatest value as a remedy, but confirms the diagnosis.

Scarlet fever.—In the course of scarlet fever, some joints, especially the smaller joints of the upper extremity, metacarpo-phalangeal joints

and wrist, are attacked with acute inflammation. The inflammation has so far a rheumatic character, that it tends to migrate from joint to joint and the pain is relieved by salicylates, but it otherwise differs from acute rheumatism. Thus it chiefly occurs in severe attacks of fever where there has been some ulceration of the fauces; also in many cases suppuration occurs, especially in the elbow, knee, and sterno-clavicular joints, also in the temporo-maxillary articulation by extension from the ear. When incised early, and the joints are washed-out, the prognosis is favourable. Or the joints may show a chronic septic inflammation resembling the course of gonorrhœal rheumatism, when mineral bath treatment, sea air, etc., is required.

Pneumococcus infection.—A purulent periostitis or arthritis, from which pure cultivations of pneumococci are obtained, follows inflammation of the pleura and lung, the commencement of the attack often being called influenza. Whilst pneumococci cause a purulent inflammation, it is not a destructive one. Early incision of a fluctuating swelling, whether it be a joint or beneath the periosteum, is likely to be followed by a speedy recovery. There is little tendency for the inflammation to lead to caries or necrosis. In cerebro-spinal meningitis arthritis may occur and diplococci be found, both by lumbar puncture and in the joints.

Typhoid fever infection.—The typical lesion caused by the typhoid bacillus is a cortical osteomyelitis, especially of the shaft of the tibia, less often of a rib or some other bone, perhaps localised by a slight injury. It is not essentially a purulent infection. A painful swelling or node forms which then softens and undergoes absorption, or a thin fluid is found round a sequestrum, formed by cortical layers of the bone. The collection of fluid beneath the periosteum may communicate with a cavity in the bone by a narrow channel, the whole cavity having the shape of a shirt stud or hour-glass. From the fluid a pure culture of typhoid bacilli may be obtained, and this may be months or years after the fever. Suppurative osteomyelitis and arthritis also follow typhoid fever, but this is a mixed infection with staphylococci, which presumably gain entrance through the intestinal ulceration.

Tuberculous disease of bones and joints.—*Cause.*—This disease is due to the action of the tubercle bacillus, to which may become added, after the stage of caseation, a mixed infection by pyogenic organisms, in particular the staphylococcus pyogenes. The tubercle bacilli are often numerous, but even when scanty to microscopic examination direct inoculation into animals proves the infection.

Origin.—The local infection is generally hæmatogenous in origin, but it may extend directly from soft parts or by lymphatics, and is often grafted on some previous inflammation. A direct inoculation by the tubercle bacillus is rare.

Seat.—The disease starts in the bone-marrow beneath the

articular cartilage of joints, in the inner layers of synovial membrane, in the end of the diaphysis of long bones, in the cancellous tissue of short and flat bones. It is rarely primary beneath the periosteum, but usually extends to it from the vascular marrow of cancellous bone. It affects also synchondroses, especially where there is a partial arthrodial surface, *e.g.*, the sacro-iliac and pubic synchondroses.

Age.—It generally appears in the young, but may commence after puberty, and sometimes appears in the aged (senile tuberculosis).

A predisposition may be inferred when the disease appears in early life, and there are multiple lesions and a family history of tuberculosis or the patient shows evidences of the strumous, scrofulous or tuberculous diathesis as defined on p. 90. In other cases, especially in children, the patient has been exposed to the effects of bad feeding and hygiene, or has been exhausted by disease, or exposed to and weakened by septic infection, *e.g.*, by measles, scarlet fever, etc., or has been generally in weak health.

Process.—The tuberculous process, as elsewhere, consists in the formation of tubercles and their caseation, followed on the one hand by fibrosis and healing, on the other hand by suppuration and its results. Around the tubercle simple inflammation is excited, which either aids in the healing, or becomes included in and added to the suppuration. The bone is affected by lacunar absorption, which may be followed by sclerosis, or by destructive ulceration or caries, by synovitis and arthritis, and in joints by ankylosis, fibrous or bony.

Tuberculous osteomyelitis or osteitis.—In a bone, whether beneath its articular cartilage, or in the cancellous tissue of its interior, the tubercle is formed by a giant-cell, which soon undergoes caseation. Around it are small round cells or leucocytes, which largely or entirely obscure the endothelial (epithelioid) cells. The surrounding bone undergoes lacunar resorption, osteoclasts in pits and leucocytes arranged on the surface absorb bone septa; or if the process is rapid, the bone septa become necrotic, and are to be felt by the finger in the débris and seen under the microscope. An inflammatory mass of granulation tissue now replaces the bone (Fig. 128). As compared with red marrow, it is less vascular, unless at the periphery, and in colour paler, becoming yellowish; as compared with fatty marrow, it is more solid and cheesy.

At this stage the bone may show general infiltration, or there may be a circumscribed mass of the size of a pea or walnut, which, softening in the centre, is surrounded by vascular bone tending to become sclerosed by new bone formation, where an active osteogenesis is going on. This may be sufficient to enclose the caseating mass, which may then be encysted in a cavity lined by a pyogenic membrane, the contents being caseous, fatty material, with a débris of detached bone septa, or large necrosed masses. Or the enclosure by inflammatory new bone may be incomplete, and there is then an extension through one or more cloacæ to the surface.

A short or flat bone may be transformed into a cheesy mass with necrosed bone and abscesses beneath the periosteum; in the case of the skull or spine the cheesy mass lies outside the dura mater.

Tuberculous periostitis is rarely primary; it may, however, be started through an open wound. Generally, extension takes place from the cancellous bone beneath. A mass of granulation tissue is found surrounding a caseous mass of broken-down pus, the compact bone on the surface becomes cancellous, and is removed by ulceration or caries, and the sub-periosteal abscess may communicate with a cavity in the bone by a cloaca.

Tuberculous arthritis and synovitis (Fig. 136).—A joint may be affected from beneath the articular cartilage, the disease being for some time latent. Suddenly one or more tubercles burst into the joint, and the bacilli so liberated, together with toxins in the caseous material, start a synovitis. In other cases the tubercles first form in the inner layers of the synovial membrane. Bacilli arrested in the tortuous capillaries of the surface-layers develop tubercles. In miliary, rapidly-disseminating cases these appear grey, in slow cases yellow. On microscopic section a row of tubercles is seen; in each a giant-cell is undergoing caseation, surrounded by a mass of small round cells. The synovial membrane around the tubercles is much infiltrated by leucocytes, and this extends into the deeper layers and into the sub-synovial loose connective tissue, which is infiltrated by small round cells and œdema; but in the early stages the tubercles are confined to the synovial surface.

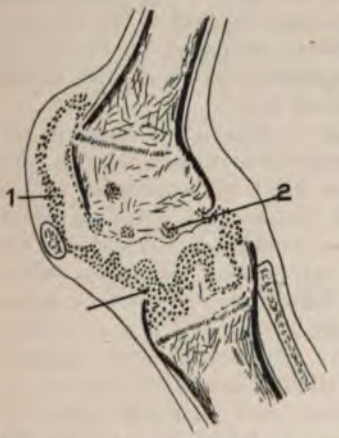


FIG. 136. — Diagram of tuberculous arthritis. 1. Tubercles forming in the synovial membrane; 2. In the cancellous bone of the femur beneath the articular cartilage; 3. Replacing the upper end of the tibia by an inflammatory mass of granulation tissue.

When the inflammation is only chronic or subacute, the tubercles may be few, the inflammation serous, so that the fluid in the joint is clear or only slightly turbid, *tuberculous hydrops articuli* or *hydrarthrosis*. If more acute, the synovial membrane is much swollen and œdematous, including all its fringes; a turbid sero-purulent fluid fills the joint with tags or gelatinous masses of fibrin, adhering or partly free in the cavity, and a section of the synovial membrane will show that it is much infiltrated by fibrin. The rapid caseation of the tubercles sets up much surrounding inflammation, and the interior of the joint becomes covered with a red mass of

granulation tissue, *villous* or *fungous arthritis*, rapidly breaking down into pus, forming a *tuberculous articular empyema*. The granulation tissue of the synovial membrane overlaps and spreads over the margin of the articular cartilage, which it meanwhile removes; whilst the same change in the cancellous tissue of the bone beneath destroys the rest of the articular cartilage. This latter appears first thinned, then worm-eaten, then replaced by vascular tissue or raised and detached in necrosed shreds.

Dry joint tuberculosis, *Arthritis tuberculosa sicca*, is characterised by the absence of purulent fluid. In its myxomatous form the synovial membrane, including its folds and villous processes, assumes a swollen, gelatinous or *pulpy* aspect from myxomatous degeneration, which also causes the articular cartilage to disappear. In other cases there are yellow caseous foci surrrounded by gelatinous fibrous tissue. Outside the joint the tissues have a glistening white, gelatinous look, and this is continued to the skin surface, which is also pale, white, smooth and shiny. Hence the name for this variety, *tumor albus*, or *white swelling*. In such a case it is at first difficult, whether by naked-eye inspection or by microscopical examination, to identify tubercles. But there follow caseous nodules becoming cold abscesses, whether discrete or fusing together. These burst through the skin and form fistulous communications between the joint and the exterior. Around the mouths of the fistulæ develop pale œdematous masses of granulations.

Terminations.—Complete resolution and return to the normal, both as regards structure and function, can only be expected when the disease has been limited to the bone, or has only superficially affected the synovial membrane. Even if all signs of inflammation have disappeared, recurrence is very likely, whether from extra movement or a return of weak health; or at some period, it may be years after, a cold abscess develops and tracks towards the surface, derived from caseous material remaining behind, the *residual abscess* of Paget.

Healing with sclerosis of bone and fibrous or bony union, synostosis or ankylosis, of joint-surfaces is the end to be aimed at. The tubercles and caseous material with bacilli are removed by the phagocytic action of fibroblasts and osteoblasts, which then form scar tissue and compact bone. The ends of the bone show sclerosis; irregular osteophytes develop round the margin of the joint where it joins the periosteum. Young fibrous tissue replaces the articular cartilage and the synovial surface, and these uniting lead to fibrous ankylosis. Later on ossification affects these fibrous adhesions, the process spreading in from the bone and periosteum.

A permanent result is more likely when the joint-surfaces are entirely united by fibrous tissue. Partial remains of the joint give rise to loculi containing fluid, and there are likely to persist small caseous foci of unabsorbed tubercle which later on relights the process.

The softening and destruction of the ligaments of the joints lead to pathological dislocations and deformities, whilst the joint becomes further deformed by irregular osteophytes around. A pathological dislocation may occur quite insidiously, before attention has been drawn to the disease, especially in the case of the hip-joint.

Supposing the tuberculous process to be arrested, preceded or not by the formation of sinuses which heal, then the bones of the ankylosed limb undergo eccentric atrophy from disuse. On anatomical examination they are found lighter, having a large medullary cavity enclosed by a mere shell of compact bone. On this account pathological fractures occur. A tuberculous process in a joint with extensions may be fatal, by (1) Miliary tuberculosis affecting the meninges or the lungs. It is surprising that this does not occur oftener and earlier. It may be noted after operations, but is uncommon and forms no bar to active measures. (2) Hectic (p. 51) and (3) amyloid disease (p. 51), which especially follow tuberculosis of bones and joints. (4) Metastases—septic intoxication with pyæmic abscesses (p. 53).

Signs.—The general characteristics of tuberculous inflammation are exhibited in bones and joints. The inflammation is insidious in onset, chronic in its course, and tends to suppuration. Early signs are stiffness, heat, and slight pain after use, or persisting after a slight injury, disinclination to use and to allow of passive movement of a joint. A cold swelling develops about the epiphysial line of a bone or distends a joint and yields a doughy elasticity, or actually fluctuates. A sub-acute synovitis attacks a joint without any sufficient external cause.

The presence of fluid in a joint, of thickening round a joint so as to obscure the bony prominences, wasting of the muscles about a joint so forming a spindle-shaped tumour, starting pains at night on dropping off to sleep, marked destruction of the cartilaginous surfaces, a slow displacement of the joint, *e.g.*, of the knee backwards with rotation outwards, a sudden dislocation of the hip without a sufficient injury—all these are signs of progressive disease. Then follow cold abscesses, containing curdy pus, around a joint, extending by gravity according to the position of the patient, downwards in the upper limb or spine, up the thigh if the patient be in bed with the knee raised.

Diagnosis.—Tuberculous disease may in its earlier stages be pronounced rheumatic. Such statements are too often the result of superficial and careless observation. The youth of the patient, the insidious onset, the affection of one joint with the absence of any history of an acute attack of rheumatic fever, should exclude any question of rheumatism, a term which has often blocked the way to timely surgical measures. In patients above puberty and in senile cases there may be more doubt, as the disease is relatively rare. Chronic rheumatism and septic infection, including

gonorrhœal rheumatism, generally affect more than one joint, and a tuberculous process may be suspected whenever one such joint persists in remaining hot, distended with fluid, and thickened. An exploratory incision is then indicated. Gummatous disease, in the absence of general syphilitic evidence, sarcoma and actinomycosis can only be distinguished by exploration. When there is pulmonary tuberculous disease, it may extend to the ribs, and pus collect beneath them, peripleuritis, in a way which is difficult to distinguish from a localised empyema.

Secondary metastases.—Tuberculous disease of the larger joints, of the spine and sacro-iliac synchondrosis, may occur in patients the subjects of pulmonary tuberculosis. A cold white swelling then appears, often advancing very slowly.

Treatment.—This should be chiefly *preventive*. Good food and ventilation, a change to the country or seaside. Fat is important in the food, whether in milk, bacon, etc., or as cod-liver oil. Slight injuries and inflammation of joints must not be ignored, but the joint kept at rest until all heat has passed, not wrenched or moved freely as has been done by ignorant bone-setters. Relapses are very common. Complete recovery is very slow, only residence in the country or seaside for months, a year, two years, may effect it.

Any fluid swelling, whether in or outside a joint, may tend to disappear on rest. If it does not in a week or two, it should be treated by injection. A cannula is inserted, the cavity washed out with sterilised water, and then injected with iodoform emulsion in glycerine (see p. 177). Some use for small collections the iodoform in equal parts of absolute alcohol and ether, or a 5 per cent. to 10 per cent. solution of chloride of zinc in about 5 minim doses. Little good can be expected from the treatment recommended for chronic synovitis (p. 326); at any rate, it should not be persisted in for long.

Incision is necessary for more extensive and rapidly-spreading disease, or where injections have failed. But simple incision with insertion of drainage-tubes is a method altogether inadequate, and harm follows by septic germs entering from without. It is necessary to remove all the disease, to excise the synovial membrane of joints, *arthrectomy*, to gouge away all diseased bone. Then after destroying any tubercles in the wall with a strong antiseptic, *e.g.*, pure carbolic acid, carefully washed away, and applying iodoform, the wound is partly or completely sewn up, or is partly filled with gauze, and the dressing changed until healing follows. After healing by fibrosis and sclerosis of bone, the general preventive treatment is required against relapse. *Excision of the joint*, the ends of the bones being removed and fibrous or bony ankylosis obtained, may be attended with a good result, but with some deformity. The tuberculous pouches must also be cleared. Excision is often insufficient when the soft parts are widely involved.

Amputation becomes necessary to prevent the patient dying of generalised tuberculosis, hectic fever, and amyloid disease. It is the more readily undertaken when the joint has been rendered useless and there is a good chance of obtaining a sound and useful stump.

Tuberculosis of the lung forms no bar to surgical procedure, unless very rapidly progressing, indeed much improvement may follow. Generally speaking, under such a complication, complete removal by amputation is to be preferred to excision, which may heal badly. Ribs may be excised to give exit to the collection beneath, except in advanced conditions.

Actinomycosis in bone attacks chiefly the lower jaw, and the process is one mainly of absorption and ulceration of bone with very little or no new bone formation. The spine is affected by extension from the pleural cavity. Metastatic disease is occasionally seen, *e.g.*, in the spongy bone of the lower end of the femur and upper end of the tibia, where the disease would at first simulate tumour or tuberculosis.

The **Madura disease,** affecting especially the bones of the foot, is described on p. 97.

Gonorrhœal arthritis.—The gonorrhœal infection enters commonly by the urethra in the male; by the urethra, vagina or cervix uteri in the female; by the conjunctiva of children; by the vulva of little girls. Only a small granular patch or a slight spasmodic contraction of the male membranous urethra may be found on examination, not sufficient to cause the patient trouble, so that he does not mention it. In a woman a bimanual examination may be required to discover distended Fallopian tubes. The occurrence of gonorrhœal ophthalmia or vulvitis in young children preceding the joint affections should be recognised. The arthritis appears generally to arise from a mixed infection, although gonococci have been found in the local lesion, also in the joints, yet often only staphylococci or streptococci. In its earlier forms the joint inflammation is due to toxic absorption only, for immediate relief follows local treatment, *e.g.*, dilatation of a largely spasmodic, urethral stricture. In later stages it is a septicæmia with metastases; not only is local treatment required, *e.g.*, removal of a pyosalpinx, but also treatment of the joints. The joints chiefly affected are, the knee first, then the wrist, ankle, elbow, shoulder, hip, and even the temporo-maxillary joint. The plantar ligaments also are affected, causing pain in the heel, and leading to flat-foot. The joint affections may be divided into: (1) Serous synovitis, hydrarthrosis, or hydrops articuli. (2) Sero-fibrinous synovitis with tendency to fibrous ankylosis. (3) Suppurative arthritis, an empyema, with slow destruction of the joint and its ligaments, followed by displacement and deformity. After discharging the pus bony ankylosis ensues in the deformed position. (4) Acute phlegmonous inflammation, great infiltration of the synovial membrane and the surrounding tissues forming multiple

abscesses without much fluid in the joint, but likely to be followed by a general septic infection.

Treatment first is applied to the point of entry, and consists in dilating strictures, treating granular patches, clearing out pockets in the female urethra, scraping the cervix, excising Fallopian tubes, applying nitrate of silver, etc., to the conjunctiva. Joints distended with fluid are kept at rest and blistered, or washed out with hot water. In the sero-fibrinous type, tending to ankylosis, the joint should be painted with iodine until the skin becomes like brown parchment. If suppuration threatens, attempts may be made to arrest it by injecting carbolic acid, 5 per cent., about 2 drms. at a time, into the joint. If subacute inflammation persists, a mercury ointment (ung. hydrargyri) should be applied over the joint every night and washed away in the morning, or sulphur ointment; or the joint is covered with sublimed sulphur, then wrapped in flannel and heated in front of the fire, and this is kept up until the sulphide appears in the breath. As soon as the inflammation has subsided, massage and gymnastics are required to overcome the tendency to fibrous adhesions. Quiet suppuration often indicates tuberculosis, and treatment follows that line—drainage, erasion, arthrectomy. The phlegmonous form requires free incision, strong antiseptics, and gauze dressing of the opened joint, and if this is not done early amputation may become necessary.

The *general treatment* is that for septic infection, a free diet, judicious use of alcohol, fresh air. Whether any drug treatment is of avail is doubtful; iodide of iron may benefit if there is any suspicion of syphilis, and improves the anæmia. Cod-liver oil is indicated in a thin, wasted patient with a tendency to tuberculosis. Guaiacum and sulphur have been praised, as well as mineral baths containing sulphur.

Syphilis of bones and joints.—*Generalised* syphilis, whether inherited or acquired, affects the periosteum and ends of the bones in joints. It also induces pyogenic and tuberculous complication when the disease is no longer amenable to antisyphilitic remedies. It should not be confused with the effects of gonorrhœa.

Periostitis occurs during the secondary stage, is situated on the shaft of the long bones, or on the flat bones, *e.g.*, the skull (Fig. 137). The periosteum is raised by a collection of small round cells beneath it, and the inflammation thickens the periosteum and extends to the soft parts around, or even to the skin when superficial. The swelling causes much pain, especially at night, and is due to acute inflammation, which results in rapid lacunar absorption of the bone beneath. If the inflammation becomes less, compact periosteal bone (Fig. 116) is formed, giving rise to a swelling or node which fades gradually into the surrounding parts, like a hill rising gently from a plain.

If it undergoes myxomatous degeneration, a semi-fluid swelling

arises, having as its floor carious bone. If the inflammation is acute, more or less necrosis of the shaft may ensue. A syphilitic sequestrum is often peculiar in having a worm-eaten (Fig. 138) rather than a smooth surface, and a dense structure, as if some sclerosis of the bone had preceded its death.

Gummata form in the periosteum and invade the bone beneath, in which case there is much difficulty in distinguishing the disease from periosteal sarcoma. On the one hand, a gumma may not yield to antisyphilitic remedies; and on the other, some diminution of congestion may follow the administration of iodide in the case of a

Fig. 137.—Syphilitic periostitis of the skull. Parrot's nodes. (From St. Bartholomew's Hospital Museum.)

sarcoma. On exploration, a gumma should be recognised by yellow points or shreds, and by the sticky, gummy fluid resulting from its degeneration. When the section appears uniform a microscopical examination is necessary to distinguish it from spindle-celled sarcoma.

Syphilitic osteomyelitis (*osteitis*) causes a general spongy or osteoporotic hypertrophy; the bone is heavy, and has a tendency to bend; the distinction between compact cancellous bone and medullary cavity is largely lost. In a young patient the bone change may easily be confounded with rickets, in old patients with osteitis deformans. If the progress is at all rapid, a sequestrum is formed from the old bone, and the consequent septic changes and the formation of cloacæ is combined with the spongy hypertrophy. Such cases are seen in

broken-down individuals, also in the severe types of syphilis prevalent in the tropics. A spontaneous fracture may occur.

However, the extensive necrosis of the skull, lower jaw, and other bones preserved in museums are not now wholly attributed to syphilis, but largely to the excess of mercury formerly given. Marked atrophy may sometimes result from syphilis, especially in the skull, *craniotabes*.

New-born infants and children deeply tainted with inherited syphilis suffer from *septic inflammation* of *diaphyses* of the long bones and ribs at the junction with the cartilages. The epiphyses may separate, one or several joints may be affected, and pus discharge on the surface. So painful is a limb that it is kept motionless, and may be thought to be paralysed. It is a septic complication, not a syphilitic process, and so not amenable to mercury. If the lesions be limited and the child survives, deformities from disturbance of epiphysial growth take place.

Fig. 138.—Syphilitic necrosis of the skull. (St. Bartholomew's Hospital Museum.)

Syphilis in the early secondary stage causes a *simple synovitis* which subsides under drug treatment, without damaging the joint. A serpiginous erosion of cartilage has been stated to accompany this synovitis.

In the later tertiary period the *whole synovial membrane*, especially of the knee-joint, may undergo a *gummatous thickening* which, until it commences to degenerate, is difficult to distinguish from chronic rheumatic hypertrophy or from diffuse sarcoma of the synovial membrane. Erasion or arthrectomy may be required to arrest the process, which otherwise will become complicated by septic inflammation and end in amputation.

Rheumatic inflammation of joints.—The term rheumatic is often used for obscure pain in bones and joints, which if further inquiry were made would be found not to be related to true rheumatic fever.

Acute rheumatism or rheumatic fever is now believed, on many grounds, to be an acute specific fever. Organisms have been found in the affected joints, but observers are not yet in exact agreement. The disease is generally polyarticular, the larger joints, the knee, ankle, elbow, shoulder, being usually affected. An acute synovitis occurs with a serous exudation into the joint, in which are some flakes of fibrin. There is redness of the skin over the joint, which is hot, but with free sweating. There is much pain, so that the

joints are held in the most relaxed position, knees slightly flexed, ankles extended, elbows flexed, wrist flexed, and the fingers slightly deviated to the ulnar side. Many joints are involved, not all at once, but in succession; the swelling decreasing in the first affected joints, whilst increasing in others. With the subsidence of the fever, the inflammation in the joints also undergoes resolution, which should be complete. The *treatment* is that of acute rheumatism, salicylates, alkalies, and a very light diet. No special local treatment is usually required; if there is much pain a splint may be applied to keep the joint at rest, also an ice-bag. If the inflammations are at all prolonged, the joints must not be allowed to become fixed in a mal-position, the knees or hips flexed, the ankles extended by the weight of the bed-clothes, lest forced movements and tenotomies be required later. In all doubtful cases the joint should be aspirated and the fluid examined. Whenever the exudation is excessive or not quickly re-absorbed much benefit follows from washing out the joint with sterilised water through a cannula inserted by means of a trocar. The puncture is afterwards covered with collodion.

Chronic rheumatic inflammation of joints is either the direct result of an acute attack, or of recurring attacks, or the disease may be chronic from the first. It is the larger joints which are affected, a single joint or many joints, mono-articular or polyarticular rheumatism. The co-existence of endocarditis, and of subcutaneous nodules especially in children, and the tendency to recurrence from exposure to cold and damp, are points which may aid in making the diagnosis. The disease may be a chronic synovitis, one or more joints remaining hot, tender, weak, and swollen by exudation; or there may be some tendency to fibrous ankylosis, causing the joint to be stiff and the adhesions yielding with a crackling noise when forced movements are made under an anæsthetic. In the worst case a progressive fibrous ankylosis slowly affects many or nearly all the joints. On the other hand, there is not a development of the changes noted as arthritis deformans, although this latter may follow acute rheumatism. The general treatment is that of acute rheumatism, salicylates, also quinine and iodide of potassium. Locally the joints must not be kept on a splint too long, or they will become ankylosed. They should be blistered if painful, but as soon as possible passive movements and massage are used, which may be commenced under an anæsthetic. Baths and douches and massage may be combined at mineral-water resorts, such as Bath, Buxton, Harrogate, Wiesbaden, Droitwich, Aix-les-Bains, etc. Great care must be taken to keep such joints well wrapped up and protected against cold and damp.

Arthritis deformans, or Chronic Arthritis. — *Varieties.* — Hitherto it has proved difficult or impossible to arrange any satisfactory classification of the various affections which result in the

changes described under *Chronic arthritis* or *Arthritis deformans* on p. 327. Some of the obscure cases have been in recent years traced to septic infection, pyogenic, gonorrhœal, etc., a toxinæmia or septicæmia of an intensity not sufficient to cause suppuration. Besides these are diseases not yet connected with microbic infection. In some of them the changes produced in the joints have been attributed to toxic products of disturbed metabolism (*gout*), to senile degeneration (*osteo-arthritis*), to congenital and hereditary degenerative tendencies (*hæmophilia*),to lesions of trophic nerves (*neuropathic joint lesions*). The disease approaches true rheumatism in following long exposure to cold, combined with hard work and poor food. As such it affected early man, as can be seen in bones taken from prehistoric graves. It is an affection of animals during senile decay, and also attacked species now extinct.

Osteo-arthritis—Chronic rheumatoid arthritis—Arthritis sicca.—This is a progressive disease of which arthritis deformans is the result. It is due to some cause or causes which continue active over a long period, affecting now only one or two, often many, joints and the adjacent ends of bone, without going on to suppuration, but attended with marked muscular wasting.

Variety 1.—*Fusiform osteo-arthritis* is a special form which occurs in children, in which all the larger joints assume a spindle shape by enlarging whilst the muscles above and below waste. True chronic rheumatic arthritis is rare in children, and so is also the typical arthritis deformans of adults. Dr. Still has described in these children the change as mainly consisting in a vascular thickening of the synovial membrane, with some fibrous adhesions, whilst the articular cartilages remain almost unchanged. The cause is unknown. It occurs before the eruption of the permanent teeth from fifteen months onwards, commencing insidiously with some pyrexia, attacking symmetrically the larger joints, the spine, then the fingers and toes. It is accompanied by enlargement of lymphatic glands, especially those in relation to the affected joints, also the spleen. The lesion is to be distinguished from other surgical affections; from rickets; from tuberculous disease by the absence of any tendency to caseation or suppuration; from congenital syphilis, which the disease most closely resembles, by the absence of other signs of syphilis and the failure of mercurial remedies. In adults the hands and feet are apt to be attacked by a thickening of the synovial membranes and effusion into joints, with enlargement of bursæ, but no osteophytes or lipping of the edges of the bones. The joints are attacked symmetrically, and gradually all the joints of the body may be involved. The lesion may also occur in women and be attended with anæmia.

Variety 2. — *Nodular and ankylosing osteo-arthritis.* — This affection is connected in origin with debilitating causes, including attacks of influenza; it affects especially women, sometimes starting

during pregnancy or about the climacteric. It sometimes begins as an acute or subacute attack, which is at first benefited by administering salicylates. It is a steadily progressive, generally symmetrical affection, attended by an irregular formation of osteophytes around the joints, whilst creaking and crackling accompany movements. The finger-joints especially are enlarged by masses about the size of peas, called Heberden's nodes, which are very similar in structure to exostoses. The hands tend to become deviated to the ulnar side, some phalanges are flexed, others extended, the knuckles are enlarged, and the palm is hollow. It is the first row of interphalangeal joints which are most affected, the distal row usually escape, and also the movements of the thumb are mostly maintained. Other joints become involved, with a marked tendency to fixation in deformed positions by contracture of wasted muscles, and the joint-surfaces become united by fibrous or bony bridges, whilst at the same time the bones undergo eccentric atrophy. The result is that the patient becomes more and more crippled, and even the temporo-maxillary joint may be involved and the movements of the jaw limited. The patients are often feeble, with a weak circulation, clammy extremities, and a pulse-rate above the normal; bronzed patches may appear on the skin (Dr. Kent Spender). They are also subject to psoriasis, varicose veins, migraine.

Variety 3.—*Traumatic or mechanical or senile osteo-arthritis.*—In this variety the disease is also progressive, but it only involves at first one joint and may remain mono-articular, or in time gradually spread to a limited number of joints. It results in marked deformity, the joints being hindered in movement chiefly by the lipping, whilst the joint-surfaces do not form adhesions. In many cases the onset is distinctly a *traumatic* one, *e.g.*, a blow or strain on the shoulder, causing a slight traumatic arthritis, or a distinct lesion, such as a detachment of cartilage, a dislocation or fracture into the joint. The arthritis, instead of subsiding, slowly progresses to deform the joint (Fig. 130), and may induce a lesion in other joints by putting abnormal strain or work on them. In other cases it is not so much a single injury, but the *mechanical* result of prolonged, excessive or irregular use of joints, as emphasised especially by Mr. Arbuthnot Lane. The patient's occupation is the exciting cause; the spine is bowed by weight-carrying, the hands of a boatman assume permanently the position of rowing, a cabman's left hand that of holding the reins, his right hand that for the whip. A woman's right hand gets fixed in the position she holds the needle, the left hand in the position she holds the sewing. A hip or knee is affected owing to excessive use when the opposite leg has been fractured or amputated, the knee tending towards a bow-legged deformity, the hip everted and slightly flexed. There is not the symmetry which has been referred to in other varieties. It is

often asserted that the disease is centripetal in its progress, spreading from the hand or foot upwards towards the trunk, but the hip is often affected before the knee. Such patients are liable to feverish attacks from rheumatic causes, such as changes of weather, cold, damp, or from causes which induce gout, and from which it is impossible to sharply distinguish some of such cases. The pains are then very sharp, and are added to by muscular spasm.

Treatment of osteo-arthritis.—The disease being essentially progressive, pain follows by disorganisation spreading from joint to joint; in senile cases, also in some more acute varieties in young people, no treatment is of any service. In others the progress of the disease may be arrested, in some even an improvement may follow. The diet is different from that of acute rheumatism on the one hand and from gout on the other, and resembles much more that suitable for cases convalescing from septic infection, viz., a generous diet, including meat and a moderate use of alcohol, such as stout. A warm, dry climate, with as much fresh air and active exercise as can be taken, baths and the hot douche, such as can be had in this country at Bath, Harrogate; abroad at Aix-les-Bains. Some derive benefit from brine or peat baths, anæmic patients from iron springs. Hot-air and vapour baths often give much immediate relief, but the joint requires to be carefully protected afterwards. Electric baths carefully applied in moderately early cases over a considerable period of time are often beneficial. The drugs most generally useful are iodide of iron, cod-liver oil and arsenic. Antipyrin, salicylate of soda, and iodide of potassium may give temporary relief from pain, but are too depressing to the general health for prolonged use. The joints require to be kept warm and dry, wrapped in cotton-wool or flannel, and acute pain is relieved by opium, belladonna and chloroform liniments. The joints should not be kept fixed on splints, but if weak may be supported by perforated elastic bandages or fitted knee-caps, etc.

Actual surgical treatment is limited, but may do good when only one joint is involved or one joint in particular is becoming rapidly disorganised. The washing out of a joint, removal of loose bodies and tags, arthrectomy, excising fibrous or fatty (*lipoma arborescens*) enlargements of the synovial membrane, at the same time putting the joint into good position, also a definite excision of a joint, are all measures which, used with circumspection, may afford relief.

Arthritis deformans from hæmophilia (see page 222).—The changes which the joints undergo in this affection are those of arthritis deformans with extravasations of blood into and around the joint. The joints generally show a diminished mobility with osteophytic nodules and lipping. The cartilage becomes fibrillated, then replaced by eburnated bone. But less often there is an excessive wearing away, the joint is very weak and loose, and there is much grating.

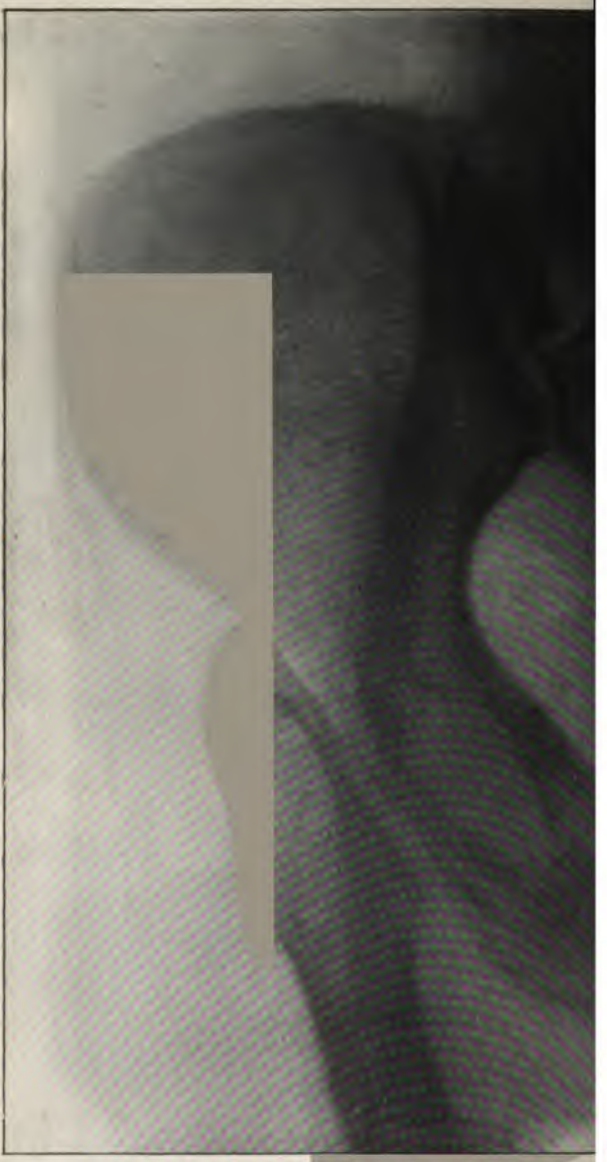
Arthritis deformans due to gout.—Arthritis deformans is referred to gout when the gouty concretions are found "dropped" (gutta) around or deposited on the articular surfaces of a joint. The characteristic gouty concretions, chalkstones or tophi, are masses of needle-shaped crystals of sodium biurate (NaHU) found interstitially in the hyalin matter of the articular cartilage, encrusting, streaking, spotting it; or in the surface layers of the bone exposed by detachment of the cartilage, in the ligaments, tendon sheaths, bursae; also in the subcutaneous tissue round the joints and in the rim of the ear (*tophi*). These crystals are either disseminated through the connective tissues or else form solid masses, which may soften to the consistency of mortar, and when the skin gives way be mixed with pus. Also the fluid in the joints contain the crystals. Typical gout commences in the metacarpo-phalangeal joints of the great toes—these joints rarely escape, and are often the only ones attacked; next are joints of the foot and ankle, then the fingers, wrists, and knees; rare joints to be attacked are the elbow, shoulder, hip, jaw, and spine. But a slight injury or mechanical disturbance may cause any joint to become particularly involved.

Gout is largely an inherited constitutional defect, combined with some derangement in the metabolism of the individual, brought about especially by alcohol and lead. Although gout is regarded as one of the causes of arthritis deformans, it does not necessarily follow that the biurate of soda is the irritant which excites the arthritis; the deposit may be only a by-product in the abnormal process.

The first attacks of gouty inflammation of joints consist in an acute synovial effusion with hyperæmia and swelling of the tissues around, including the skin. Such acute inflammation is often relieved by lead and spirit lotion, by belladonnna extract in glycerine, or by poppy-head fomentations. Subacute inflammations often benefit by lithia-water fomentations, a saturated solution applied on lint which is kept wet, but is not covered by oiled silk lest an eczema arise. For eczema and itching and ulceration, ointments of zinc, bismuth, lead, or boric acid with vaseline or lanolin are used. Internally, mercury pills, colchicum used with care, and Dover's powder of opium and ipecacuanha are suitable for the acute phases, and for chronic cases, lithia, piperazin, or one of the various mineral waters. The diet is directed mainly to the general improvement of the patient, but is not specially restricted as regards meat or alcohol; the patient soon finds out for himself and learns to avoid those things which do harm.

When a tophus ulcerates and chalkstones are exposed, bathing in hot water several times a day helps to dissolve the concretions and to favour healing. In old people further surgical measures should be avoided. In relatively young and healthy subjects, gouty concretions, ganglia and bursæ which impair movement may be occasionally removed with advantage.

PLATE III.



Skiagram of Charcot's disease of the hip-joint. The extensive destr
and neck of the femur is well shown. (Taken by Dr. Hugh

Neuropathic arthritis deformans.—*Nerve paralysis* is followed, *e.g.*, after division of the median or ulnar nerve, in the finger, by painful swellings of joints, roughening of the articular surfaces and later by some fibrous adhesions. Similar swellings of the hip or knee may follow spinal-cord injury and compression, or the shoulder may be affected in hemiplegia. It is possible, however, that an unnoticed traumatism may give rise to the inflammation, for joints do not necessarily suffer in this way. Similar joint lesions have been noticed in alcoholic peripheral neuritis, and have improved under treatment of the neuritis.

Arthritis deformans of tabes—Charcot's joint disease.—It is very likely the case that the arthritis is started by slight injuries, for joint lesions occur in perhaps not more than 10 per cent. of all cases of tabes. Also only one joint may be affected, or one chiefly and others not markedly, or the joint affections may be symmetrical. It is therefore difficult to understand the connection with the nerve lesion, except by a chance injury, or the mechanical influences which induce osteo-arthritis (see p. 347). The joint movement may be somewhat more excessive in consequence of the diminished sensation, and more irregular. Broadly speaking, the arthritis deformans of tabes is similar to that of osteo-arthritis, except that there is mostly a greater tendency to wearing away, the joints become looser, and undergo spontaneous dislocation. On the other hand, enormous bony osteophytes may form around a joint and fix it, even after a period of excessive mobility. Within a loose joint is oily synovial fluid, hypertrophied fibrous and fatty folds of the synovial membrane, and loose masses of bone. Diverticula of the capsule may extend outwards beneath the muscles as cysts communicating with the joint.

Both men and women are attacked; invariably in the latter and in the majority of the former, the patients have had some syphilitic affection. The lower extremity is especially affected, the knee, hip, ankle; also the tarsal, metatarsal, and toe-joints. After these in order of frequency are the shoulder and temporo-maxillary joints, whilst the elbow, wrist and fingers generally escape.

The joint affections may occur quite early in the disease, and only on careful examination is some early sign of tabes detected, such as loss of the patellar reflex, the Argyll Robertson pupil, or an unsteadiness when the feet are placed together and the eyes are closed.

A typical attack of Charcot's disease at this early stage consists in an acute swelling of a joint, without much pain, or other signs of inflammation, and when the swelling subsides preternatural mobility and grating between the joint surfaces. At a later stage the ataxic symptoms become more definite. Then the affected joint is excessively loose, yet painless, *e.g.*, the knee may show lateral movement through 30 to 40 degrees, with loud grating, much fluid separating the surfaces, or spontaneous dislocation. A remarkable

quiet absorption may occur, the head and upper third of the humerus may disappear by absorption almost unnoticed until the condition resembles an excised shoulder. The feet have shrunken so as to look like those of a Chinese lady, owing to the atrophy of the tarsus and metatarsus; or around a joint there is excessive lipping, the head of the femur becomes mushroom-shaped, the acetabulum flattened, and irregular masses of compact, and even ivory-like bone may be seen, as in osteo-arthritis. In consequence of disuse bones and muscles undergo atrophy and spontaneous fractures occur.

Treatment.—During the acute attack the joints are kept at rest with extensions to prevent dislocations, covered by evaporating lotion, and pain is relieved by opium. Between the attacks active use should be encouraged to prevent the atrophy of bone and muscle mentioned above. Occasionally, when a single joint has been attacked, it has been washed out, loose bodies removed, fatty and fibrous masses growing from the synovial membrane excised, or the joint surfaces trimmed to allow of the joint being fixed in a good position.

Arthritis deformans of syringo-myelia—Gliomatous arthropathy.—The disease of the spinal cord, which some have regarded as being due to an increase of neuroglia with secondary degeneration, others to a central myelitis and softening, is situated mainly in the cervical and upper dorsal region of the cord, and it is the joints of the upper extremity which are nearly always attacked, and then generally on one side, not symmetrically. It generally occurs in males, presumably because of the greater liability to injuries of the upper limb. In syringo-myelia there is analgesia, loss of perception as regards heat and cold, irregularly distributed, and trophoneuroses affecting the fingers, the latter type being known as Morvan's disease. There is no ataxia. Owing to the analgesia the patient may burn the fingers, but apart from this pustules and whitlows develop, the nails fissure and crumble, the finger-joints enlarge, necroses of phalanges follow, also extension of suppuration to tendon-sheaths and joints, so that the original nerve lesion becomes complicated by septic changes. A trophic theory is here not necessary; the lesions can be explained as due to vaso-motor changes, along with the loss of sensation predisposing to slight injuries. But besides these changes in the extremities and their septic complications, there are changes in the larger joints; in 80 per cent. the shoulder or elbow is involved. There is a sudden swelling of the joint; in the earliest stage there may be pain, but later sensation is diminished. The joint becomes enormously enlarged with much thickening, which may be confused with tuberculosis or tumour. Examination by the *x* rays shows a great destruction of the ends of the bone, also to some extent irregular exostoses and osteophytes around the edges, the one tending to loosening, the

other to fixation of the joint. In the interior of the joint is a sero-fibrinous fluid with irregular masses of synovial membrane. Spontaneous fracture may occur and union follow with excess of callus. A spinal curvature develops slowly.

Treatment.—Active surgical interference is called for in the septic complications, *e.g.*, drainage of suppurating joints.

Pulmonary hypertrophic osteo-arthropathy.—The connection between clubbed or drumstick finger ends and lung disease was observed by Hippocrates (Hippocratic fingers). But further changes

Fig. 139.—Pulmonary hypertrophic osteo-arthropathy. Photograph of a man who died at the age of 21, having had tuberculous disease of the tibia at 16, then spinal caries and psoas abscess, and finally pulmonary tuberculosis. (Copied, by kind permission, from Messrs. Thornburn and Westmacott's paper in the "Transactions of the Pathological Society," 1896.)

involving widely the skeleton have been described of late years, and special information has been obtained by examination with the *x*-rays. Various pulmonary affections, bronchiectasis, chronic empyema, chronic phthisis, and malignant disease of the pleura, produce changes in the bones, whilst congenital heart-disease and rapid pulmonary tuberculosis merely cause enlargements of the soft parts from venous congestion. The affection has also followed an attack of influenza which had left no discoverable pulmonary lesion. It begins and is most marked in the hands and feet (Fig. 139), the larger joints and the spine being afterwards involved. The fingers are increased in length and thickness by new periosteal bone (Fig. 140), the terminal phalanx being enlarged; and the nails

striated, fibrous, long, are curved over towards the finger-pulp like a claw, and have a clubbed, drumstick or hour-glass shape. The carpo-metacarpal joints are not much affected; the wrist-joint is swollen, and the ends of the radius and ulna enlarged to a thickness greater than the upper part of the forearm. The toes, ankle, and lower ends of the tibia and fibula are similarly affected. Effusion takes place in many joints, especially the knee, with erosion of cartilages. There is a tendency to spinal kyphosis, a curve forming in the lower dorsal region. The new periosteal bone is at first

Fig. 140.—Hand of the patient, Fig. 139, to show new periosteal bone and erosions of the joint-surfaces.

cancellous, but becomes more and more compact; there is eccentric atrophy, especially at the ends of the long bones.

Mother-of-pearl-dust periostitis.—Young mother-of-pearl turners, ages sixteen to twenty, especially in Vienna, in small workshops, six to twelve months after commencing the work suffer from a peculiar often multiple periostitis. The attacks begin suddenly with acute periosteal effusion about the ends of the shafts of the long bones, which spreads towards the middle or may even extend to the epiphyses. There are alternating remissions and exacerbations; the swellings, at first soft or even fluctuating, come to be composed of dense periosteal bone. The bones affected have been the metacarpals, metatarsals, tarsals, bones of the forearm and arm, the fibula, femur, scapula, clavicle, upper and lower jaw. Neither necrosis nor spontaneous fractures are seen. No post-mortem examinations have been

made. The disease seems to be closely allied to pulmonary osteo-arthropathy, the dust inhaled causing chronic pulmonary inflammation.

Osteitis deformans.—(1) *Osteitis deformans of Sir J. Paget.*—This is a senile disease which affects the skeleton in both men and women, without for a long time being accompanied by any visceral disease, although at last there is a tendency to the development of new growths.

Pathology.—The disease shows connections with osteomalacia as regards absorption and bending of bone, with rickets or syphilis in causing a chronic hypertrophic osteitis producing spongy osteoporotic bone, with arthritis deformans in its irregular bone formations about joints, and with sarcoma of bone. A very chronic inflammatory hypertrophy, both periosteal and central, causes a long bone to increase enormously in thickness, with some interstitial growth in length. The bone on section appears uniformly osteo-porotic or spongy, the distinction between compact and cancellous bone is lost and the medullary cavity is partly filled up, or in its irregular cavities is a reddish material approaching myeloid sarcoma in structure. With this there is bending of the shafts of the long bones, of the neck of the femur, and of the spine.

Symptoms (Fig. 141).—Attention is first drawn to the disease by the bending of the limbs and the enlargement of the head. The shaft of the femur bends forwards and outwards, whilst it is everted by the sinking downwards of the neck, the knees are wide apart, the tibiæ bend forwards, the shin is rounded and nodular; the ankles are together. The skull is much enlarged, not so the face; the head bends forwards until the chin almost touches the sternum; the vertebræ sink together and produce a kyphosis. The clavicles are enlarged and their curves increased; the ribs fall in so that the chest cannot be expanded, and the patient becomes dyspnœic; the abdomen protrudes. The upper extremity whilst enlarging is not so much curved except the forearm, which is bent backwards by resting on the pronated hand. The spine in curving becomes much shortened; thus the arms hang lower than usual, and the whole aspect and gait of the patient has been likened to that of an anthropoid ape. There is muscular wasting, but the bones of the hands and feet remain practically unaltered, as also do the bones of the face.

The patient suffers chiefly from neuralgic pains, in the later stages from dyspnœa. Death may ensue from pulmonary, or heart and kidney complications connected with atheroma. But five out of eight cases described by Sir James Paget died of malignant disease, sarcoma in the cerebellum, lympho-sarcoma in the viscera, multiple sarcoma of bone (when spontaneous fractures appear).

Post mortem, the bones, whilst enormously thickened, may be cut through with a knife or quite easily sawn through. The calvarium, for instance, is one to two inches thick and composed of

uniformly spongy, imperfectly calcified bone, all distinction between the diploë and the outer and inner tables being lost. Apart from

FIG. 141.—Photograph of a skeleton on one of Sir James Paget's cases in the Museum of the Royal College of Surgeons. (Copied from his paper in the "Illustrated Medical News," 1888 and 1889.)

typical cases, the disease has been noted in a single bone, but then seems rather to be of the nature of a diffuse sarcomatous growth. Sometimes the disease occurs in place of senile osteomalacia, *e.g.*, in

a woman aged 88, and in her daughter aged 60, both suffering from senile dementia.

(2) *Osteitis deformans of von Recklinghausen—Osteitis fibrosa osteoplastica.*—This is a rarer disease, and more irregular as regards its clinical course, but of interest because it appears to be connected with osteomalacia, the osteitis deformans of Paget, and sarcoma. The disease shows, like puerperal osteomalacia, a multilocular cystic condition of the marrow, but in addition fibrous masses, cysts, and solitary or multiple masses of sarcoma replace the fatty marrow. The cysts contain serous fluid, also pigment or recent blood. The sarcomatous masses are myeloid or lympho-sarcoma. Or the bones may be much enlarged by fibrous, incompletely-ossified bone.

Generally it is the shaft of the long bones which suffer. In a case of Prof. Virchow's there was a general hyperostosis of the skeleton, including the skull, with bending of the femurs and the right humerus. There was a porous condition of other bones, especially the upper ribs. The interior of the bones contained cystic fibrous material, in other parts islands of fibro-cartilage, in other parts again ivory-like masses of sclerosed bone.

Leontiasis ossea, see *Upper jaw*.

III.—New growths or tumours of bone.

Chondromata, enchondromata or cartilaginous tumours grow from cartilage; at least it would seem best to limit the term chondroma to the tumours which grow from cartilage. Other tumours which contain a cartilage-like material are now recognised to be degenerating sarcomas, or to belong to the class of tumours of variable composite structure described under *Endothelioma*. A chondroma consists of hyalin cartilage, having a hard, nodular outline, is encapsuled, and shows a translucent bluish-grey section. Chondromas ossify and become exostoses (see below), or may undergo myxomatous degeneration.

Fig. 142.—Cartilaginous tumours of the bones of the hand. (From Druitt's Surgery.)

A *pure chondroma* not ossifying is of rare occurrence. It is met with on the hands (Fig. 142), affecting the phalanges and metacarpal bones, more rarely in the feet and other bones. The hands become deformed by a number of tumours which grow from within the shaft of the phalanges and metacarpals (*enchondrosis*), or from the surface (*ecchondrosis*), presumably from remnants of cartilage, from the ossification of the shaft in cartilage or at the epiphysis. The result is an increasing deformity of the hand, with pain, paralysis, and ulceration of the skin from involvement of nerves.

of the periosteum, but are very rare, except as an epulis from the periosteum of the jaw underneath the gum, or as a naso-pharyngeal polypus. Fibrous masses grow in joints from the synovial membrane.

Lipomata or fatty tumours grow from the outer layer of the periosteum, but are very rare. Lipoma arborescens is a lobulated fibro-fatty mass growing from the ends of the bone in cases of arthritis deformans.

Malignant disease of bone.—Malignant disease of bone may occur either primarily, or secondarily by metastasis or by invasion. Primary growths are usually single, but exceptionally multiple from the beginning; secondary growths are generally multiple, but exceptionally a single metastatic growth may be observed. The primary growths are always sarcomatous; the secondary growths may be either sarcomatous or carcinomatous. Besides actual tumours, malignant disease promotes changes in the osseous system of a widespread nature, having resemblances to osteomalacia and osteitis deformans, *q.v.*

Fig. 143.—Periosteal sarcoma of femur. (St. Bartholomew's Hospital Museum.)

Primary sarcoma of bone.—This may be periosteal or endosteal in origin. The periosteal sarcoma is usually a round-, spindle- or mixed-celled sarcoma, the endosteal, especially a myeloid sarcoma, less often a round- or spindle-celled. Rare endosteal tumours are small myelomas or lympho-sarcomas of bone and endothelioma (see *Tumours*).

(*a*) *Periosteal sarcomas* spring from the deeper layers of the periosteum; a rare growth from the outer layers has been termed a *parosteal* sarcoma. They rapidly invade the bone beneath and the soft parts around, spread out into muscles and along inter-muscular planes, enter the veins and grow along their lumen, invade the lymphatic glands corresponding to the part, and by means of both the venous and lymphatic stream reach the blood. Then metastases appear, especially small, scattered nodules on the surface of the lungs, with a blood-stained exudation into the pleura. Meanwhile, if superficial, the primary growth may fungate, or some calcification and ossification takes place, spiculæ forming at right angles to the axis of the bone; spontaneous fracture occurs. They may develop anywhere, the lower third of the femur being the commonest seat (Fig. 143).

Symptoms.—In a typical case of periosteal sarcoma, a rapidly-growing tumour is observed connected with the bone, not usually

painful nor attended with signs of local inflammation or general fever. The swelling is soft, semi-fluctuating, or doughy in consistence, or hard in some parts and soft in others. Over the surface may appear tortuous veins, and the lymphatic glands connected with the part may be enlarged. The patient is commonly a young adult, often gives a history of an injury to the part, and may lose weight and strength before definite signs of cachexia set in. The history is not of long duration, not more than three months.

Diagnosis.—A periosteal sarcoma has to be distinguished from gummatous periostitis, but even when the history is negative and syphilitic remedies fail, yet an exploration may reveal a gumma, either to the naked eye or on microscopic examination. It must also be distinguished from inflammatory periostitis, *e.g.*, set up by an injury. This is difficult when the sarcoma grows rapidly, or is attended by local inflammation and a rise of temperature. Indeed, suppuration with necrosis may occur in connection with sarcoma.

FIG. 144. — Endosteal myeloid sarcoma in head of tibia. (St. Bartholomew's Hospital Museum.)

Prognosis.—This is the worst possible in all true cases of periosteal sarcoma. No case appears ever to be cured.

Treatment. — Amputation as far as possible above the growth, with excision of lymphatic glands, *e.g.*, for periosteal sarcoma of the lower end of the femur, an amputation through the upper third or hip-joint, with excision of the glands in the groin, may possibly prolong life to a year or a year and a half, after which the first signs of metastases may be a blood-stained pleural effusion. It follows that as an amputation does not cure nor prolong life materially, amputation may be delayed in any case where gumma or chronic periostitis is still a possible diagnosis.

(*b*) *Endosteal sarcomas* are of much slower growth, and a very much more favourable kind for treatment.

(i.) *Myeloid sarcoma*, or giant-celled myeloma, is the most frequent endosteal tumour (Fig. 144). Its growth is slow, and it may be a year or more before it extends beyond the limits of the bone. A boring pain may be caused, then a more or less uniform swelling, generally of the articular end of a long bone, the swelling at first having the resistance of bone, then yielding and softening occur in places, and the thinned-out shell of bone occasionally gives rise to a peculiar sensation when the tumour is palpated, called egg-shell crackling, a sign much more often talked of than met with.

Having perforated the shell of bone, the tumour increases rapidly, softens, and often pulsates.

Myeloid sarcoma occurs most frequently in the lower end of the femur and in the upper end of the tibia (Plate VI.), but also in the cancellous ends of other long bones. It is also met with in the lower and upper jaw, clavicle, pelvis, and in other short bones.

The *diagnosis* has chiefly to be made from chronic central osteomyelitis in the early stages, and from aneurysm when the tumour pulsates. From central osteomyelitis it must be distinguished by exploration when the characteristic appearance of myeloid sarcoma is met with. It is likely to be confused with aneurysm when growing in the line of the iliac and femoral arteries from the pelvis, and from the upper or lower end of the femur. In the upper end of the tibia extending out into the calf vascular tumours have been met with, called aneurysms of bone, but on examination some tumour substance has usually been found.

The *prognosis* is very good if the growth be removed completely. Metastasis is much delayed, only taking place after two years or more.

Treatment.—The tumour must be scooped out, the wall thoroughly scraped, or the cautery applied; then the shell is crushed inwards, and the remainder of the cavity filled with gauze. When the growth has extended and destroyed the shell of bone a suitable excision is performed, according to the position of the growth. When the disease has spread beyond the bone to the soft parts or threatens to fungate, then an amputation is necessary through the limb just above the growth. The result is very favourable, no recurrence taking place if the primary growth is freely removed.

(ii.) *Chondro-, osteo- and cystic sarcomas*, not myeloid, are usually endosteal, round- and spindle-celled sarcomas. They are more malignant than myeloids, but more favourable for operation than true periosteal growths.

(iii.) *Small-round-celled sarcoma or myeloma.*—Lympho-sarcoma of bone is an endosteal growth which has appeared occasionally in one of two forms:

(*a*) A single local tumour grows in the marrow and enlarges the bone slowly until a spontaneous fracture occurs. On exploration, a greyish-white tumour, solid or with cysts, is found, having under the microscope the structure of a small-round-celled sarcoma.

(*b*) A multiple or diffuse tumour formation occurs in the skeleton, with new growths in the spleen and in lymphatic glands not specially connected with the tumour, whilst the urine is milky from the albumose of Bence Jones. According to Dr. Bradshaw, the bones most affected are those of the thorax, vertebræ, sternum, and ribs. As compared with osteomalacia, the disease is commonest in men; the skeleton is brittle, but does not bend; the composition of the bones is not altered by absorption of calcareous matter, but fractures occur simply on account of the absorption by the tumours, the bone

PLATE VI.

Endosteal myeloid sarcoma in the head of the tibia. (From a skiagram taken by Dr. Hugh Walsham.)

[*To face p.* 362.

becoming so thin that it can be cut through with a knife. The tumours consist of small-round-celled masses, which may become cystic, but there is not a formation of fibrous tissue as in osteomalacia. The new growth fills the medullary canal and absorbs bone, and the same growth is found in the spleen and lymphatic glands. The patient gradually becomes exhausted with dyspnœa and marked vomiting. The milky urine, containing albumose, is of diagnostic importance at an early stage. The disease has lasted as long as six years after the first albumosuria.

(iv.) *Endothelioma* has been suggested as an explanation of some rare endosteal tumours of bone, which have been called from their arrangement alveolar sarcoma; or from their large epithelioid cells, primary carcinoma of bone; or from containing hyalin material, chondromata; or from becoming cystic, cysts of bone. When such tumours are vascular and pulsating, a possible explanation is afforded of the so-called aneurysms of bone in which myeloid sarcoma material has not been found in the walls; also of thyroid-gland-like tumours. The tumours thus referred to have occurred in the bones above and below the knee.

Fig. 145.—Secondary carcinoma of the shaft of the humerus causing spontaneous fracture of the bone. (St. Bartholomew's Hospital Museum.)

Secondary malignant disease of bone.—Both carcinoma and sarcoma cause metastatic growths in bone. Carcinoma is never a primary growth, but is always secondary. Squamous-celled carcinoma may spread by extension, *e.g.*, in the case of an epitheliomatous ulcer of the leg, or to the jaw from the lip. It is but a rare cause of metastatic growths which may then be single, *e.g.*, from the œsophagus. It is mostly spheroidal-celled carcinoma which infects bone by metastatic growths, especially from the breast, less often from the thyroid gland, and rarer still from the prostate. Columnar-celled carcinoma of the rectum or intestine may occasionally give rise to a secondary metastatic growth. Sarcoma is also secondary, whether it arises in the soft parts or in bone itself. Melanotic sarcoma starting in the skin or orbit may develop metastases in the spine or pelvis. The bones especially affected by metastases from cancer of the breast, are the vertebræ, femur, humerus, ribs, pelvis, sternum. The skull is especially affected by thyroid metastases. At first the cancer cells may tend to new periosteal bone formation, probably by setting up some venous obstruction (see p. 292), but the later result is softening of bone or cancerous osteomalacia, bending, and fractures. A short bone like

the sternum may show no external tumour, yet be soft and easily cut with a knife. Then its interior will on microscopic examination show the structure of the primary growth, *e.g.*, of the breast.

Treatment.—When epithelioma has spread to bone a wide removal is necessary, seeing that on reaching the medullary cavity the growth quickly extends along it. This may call for removal of all the bone, amputation of the leg, excision of the lower jaw. If only the surface is involved a free gouging away until healthy bone is reached may suffice. Rarely in other cases is any surgical measure indicated, the patient being treated medically in bed. Metastases in the liver, lungs, etc., being absent, the removal of a single metastasis in a bone may prolong life; indeed, this has been done without the primary tumour, *e.g.*, œsophageal cancer, being discovered.

Cysts in bone.—Some of those described as such would be now recognised as due to quiet central osteomyelitis. The blood cysts are probably in all cases degenerating sarcomata. Dermoid cysts are occasionally found in the line of sutures of the skull.

Cysts of the jaw are considered under *Diseases of the Jaws.*

Hydatid cysts affect the diaphyses of the long bones, converting the shaft into a spindle-shaped thin-walled tube, which undergoes spontaneous fracture. The periosteum is not involved. The fractures do not unite. The epiphysial ends are excavated, and the hydatids may burst into joints, but do not seem to occur primarily there. The hydatid cysts have no adventitious sac, but occur in grape-like masses (Fig. 60, *g*). Suppuration may complicate the disease by which the hydatids are killed and then discharged from the abscess, but the patient suffers from septic absorption and may die from pyæmia.

The skull, vertebræ, pelvis, humerus, femur and bones of the leg and forearm are most commonly affected. It is difficult to understand how, but hydatids have developed after injury to a bone, after an ordinary traumatic fracture which united well, after a well-marked blow on the bone, and in one case after a charge of shot had entered the arm.

Treatment.—An early free incision is made, the cavity cleared out and stuffed with gauze. Amputation should be reserved for extensive suppuration.

Aneurysms of bone.—It is doubtful whether aneurysm in bone occurs. The degeneration of myeloid sarcomas, of thyroid metastases, possibly of endotheliomas, are generally held to account for the cases which have been so described.

Sarcoma of joints.—*Primary sarcoma* of joints is a very rare disease, which has been met with in the knee, also in the ankle, under two forms. (*a*) A localised lobulated mass growing from the synovial membrane not causing hæmorrhage, and recognised by palpation as a soft synovial outgrowth. Microscopically, the characters are perhaps those of endothelioma. It can be removed

by local excision, and has not recurred. (*b*) A diffuse sarcomatous degeneration in the synovial membrane, also not accompanied by hæmorrhage, and indistinguishable in its early stages from tubercle. Possibly it may be treated by arthrectomy, but any sign of rapid growth or of recurrence must be immediately counteracted by amputation.

Secondary sarcoma of a joint is generally the extension into the joint of a myeloid sarcoma. When the joint becomes distended by débris of the tumour and blood, and sarcomatous masses fungate into it, amputation is indicated.

DISEASES OF MUSCLES AND TENDONS.

Atrophy of muscle. — *Atrophy from loss of nerve control.* Whether from compression or division of a nerve, a muscle wastes by its fibres becoming smaller in diameter, with an increase of intermuscular fibrous tissue. Very late the longitudinal striations are lost, and the fibres ultimately disappear, leaving scar tissue with or without brownish pigment. The muscle has lost its tonus, is atonic, flabby; it wastes in bulk from a shrinkage of its individual fibres, and if sensory nerves are still connected with it the interstitial myositis may make the muscles tender. There is a loss of irritability to the interrupted current; at first an increase, then slowly a decrease, of irritability to the constant current, but the muscle may still respond after a year or two. Also the reaction of degeneration appears. Surgical treatment is chiefly concerned with the uniting of the nerve.

Muscular atrophy in joint disease.—Inflammation, acute or chronic, tending to limit the use of the joint, is attended by rapid muscular wasting, a shrinkage in the diameter of the muscular fibres, and also an interstitial inflammation. There is an increase of tendon reflex and of irritability to touch (myotatic irritability, fibrillar twitchings). The muscles chiefly affected are those which extend the diseased joints, the quadriceps as extending the knee; the calf muscles, the ankle; the glutei, the hip; the extensors of the forearm, the wrist; the biceps, the elbow; the deltoid, the shoulder; the interossei, the finger-joints. Wasting is observed within a week or ten days; in an acute case it progresses for two or three weeks, and then becomes stationary.

The treatment is that of the joint concerned, followed by massage and passive and active exercises. Splints may be required to prevent overstretching of the extensors and contracture of the flexors.

For other muscular atrophies see a work on Medicine.

Hypertrophy of muscle.—Hypertrophy of voluntary muscles of a true character is seen in athletes, also in some slight and early cases of acromegaly, also in the arm or leg when the opposite limb is useless. Hypertrophy of unstriped muscular tissue partly mixed

with fibrous tissue occurs in the intestinal wall and the coat of the bladder in order to overcome obstruction. The muscles of the calf are much enlarged by fat formation in the connective tissue of the perimysium in pseudo-hypertrophic paralysis. (See a work on Medicine.)

Inflammation of muscle or myositis.—Myositis may be *traumatic* in origin, a sprain or partial rupture with extravasation of blood (see *Injuries of muscle*), and may end in contracture (see *Wryneck*).

Suppurative myositis may follow an injury or rupture, or be pyæmic. A swelling, soon forming an abscess, takes the shape of the whole muscle, *e.g.*, the pectoral, or may be limited by tendinous intersections, as in the case of the rectus abdominis. A free incision parallel to the axis of the fibres is necessary. Pressure from a splint may cause an open sore, followed by myositis and contracture.

Rheumatic myositis is generally traced to a chill, causing the affected muscle to be tender and stiff. Superficial and exposed muscles are most likely to suffer. *Treatment.*—Rest, salicylate of soda internally, and belladonna extract locally.

Tuberculous myositis. — The muscles may become affected by extension from tuberculous bones and joints; *e.g.*, the psoas muscle, in the case of spinal caries.

Syphilitic myositis appears either as a syphilitic induration leading to contracture, or as a gumma tending to soften, both in congenital and acquired syphilis. The localised swelling in the sterno-mastoid of infants, which leads to wryneck, though in most cases due to rupture, may be the result of syphilis.

Muscular spasms and cramp.—There is not only loss of voluntary movement and excess of involuntary and irregular action, but as long as the sensory nerves are intact pain, which may be excessive.

Writer's cramp or scrivener's palsy is the best known of a number of conditions connected with the over-use of muscles in various occupations. *Treatment.*—Rest of the over-used muscle and general improvement in health.

Reflex spasm may be set up by some source of irritation, such as a bullet, a carious tooth, enlarged glands. When affecting the facial muscles and causing great pain it is known as histrionic spasm. Unstriped muscle is affected, especially when peristaltic movements are obstructed, as in intestinal, biliary, or renal colic. Removal of the cause is the necessary treatment.

Aches, stiffness, loss of power, rigidity of muscles occur in anæmic patients, in legs congested by varicose veins, in patients suffering from some arterial obstruction, also from cold and exhaustion as in bathing, which latter renders the person at once helpless, so that he may drown even in shallow water unless rescued.

Contracture of muscles.—A single muscle, or a group of muscles having the same function, or all the muscles of a limb, may undergo contracture, either as the result of an inflammation in the muscle itself or following upon paralysis. The result in either case is that the muscle fibres are replaced to a variable extent by scar tissue, which shortens the muscle, draws on its tendon, and also involves surrounding aponeuroses in the process, and ends in deformities of joints or of the whole limb. The muscle or muscles affected have lost their active movement, appear shrunken and hard, and may show the reaction of degeneration, whilst the tendon forms a tight band, resisting a restoration of the deformity.

Treatment.—In early stages the deformity may be prevented by fixing the limb in splints and applying extension to resist the shortening; also by massage and gentle passive movements or stretching in the direction opposite to the contracture. When the contracture has become definite, division of the tendon, or its lengthening is required.

Flaccid paralysed muscle.—As a result of the action of the group of muscles opposed to the paralysed group, contracture does not take place, but the flaccid paralysed muscle is unduly stretched. *Treatment.*—The tendon of the paralysed muscle may be shortened, or tendons of still active muscle may be transferred by implantation into the paralysed one.

Volkmann's contracture the result of ischæmia and interstitial myositis.—Venous congestion of a limb, whether as the result of excessively tight bandaging, the swelling of the limb under a plaster-of-Paris bandage, the use of Esmarch's bandage favouring embolism or thrombosis of large vessels, as the axillary or femoral artery, or as the result of severe cold, may set up acute interstitial myositis, followed by contracture and rigidity of the muscles. The onset is rapid, within twelve hours in severe cases, and is attended with loss of voluntary movement and venous congestion of the fingers or toes. Pain is rarely felt at first, hence there may be delay in noticing the condition, but when the bandages are removed the forearm is found hard and very tender. The fingers become flexed, the wrist and metacarpo-phalangeal joints extended, the interphalangeal joints of the fingers and the terminal joint of the thumb also flexed into the palm, but when the wrist is flexed the fingers can be extended. In a very bad case the wrist is flexed, the hand pronated, the forearm semi-flexed. The flexors of the forearm and hand waste, but there is generally no reaction of degeneration nor nerve lesion unless a nerve be involved in fibrous tissue. The lesion is simply due to *ischæmia* or deficient circulation, which stops short of causing gangrene. An examination of the muscles shows them to be shrunken, firm, dry, and wasted, with a great increase of interstitial fibrous tissue. This disease must not be confused with contracture due to pressure only.

Treatment.—Massage and electricity are attended by good results

if started early and continued. Lengthening of the shortened flexor tendons has been partially successful. Removal of a section of bone from the forearm so as to relax the flexors is not so certain, since it has been followed by fibrous union or non-union of the divided bones.

Tenotomy is the operation for dividing a contractured tendon to allow of the reduction of a deformity. This reduction causes the cut ends of the tendon to separate to a variable extent. The gap thus formed is first filled by blood-clot, then follows a proliferation of connective tissue and endothelial cells from the tendon sheath, which remove and replace the blood-clot and surround the ends of the tendon for some distance beyond the divided ends, as callus does the ends of bone. These cells become spindle-shaped and arrange themselves in rows parallel to the axis of the tendon. During the second week this new cellular tissue becomes vascularised, whilst between the rows of cells appear parallel connective-tissue fibrils, which come to resemble tendon, especially when the tendon ends are but little separated, and then free movement of the tendon in its sheath results. The wider the gap, the more is the splice of connective tissue intimately connected with the tendon sheath; it then remains more like scar-tissue and fixed to the surrounding structures, so that there is little movement of the tendon within the sheath. Tenotomy is performed by the subcutaneous or by the open method.

Subcutaneous tenotomy consists in making a puncture with a narrow knife or tenotome, and then, with the tendon taut, dividing it either from within outwards by first passing the knife beneath the tendon, or from without inwards by first passing the knife between the skin and tendon. As the knife is withdrawn a small pad of aseptic gauze is placed on the puncture and fixed by strapping or collodion. The subcutaneous method was important in former days from the lessened liability to septic infection through the punctured wound. The objections that have been raised, namely, the incomplete division of the tendon or of its contracted sheath, the injury to neighbouring vessels or nerves, and the extravasation of blood which may occur and which has to be absorbed during the process of healing are chimerical.

Open tenotomy, now employed by some to avoid the above, as we think, imaginary dangers, consists in cutting down upon the tendon, raising it by a hook, dividing it and any other constricting bands until the deformity can be reduced, then arresting hæmorrhage and suturing the wound. Except for division of the hamstrings we do not, as a rule, employ it.

Lengthening or advancement of a tendon.—Instead of cutting a tendon transversely across and allowing its ends to separate, a **Z**-shaped incision may be made, and the obliquely-divided ends made to slide on one another without complete separation until sufficient elongation is obtained; they are then united by suture.

Shortening of a tendon may be done, partly to restore power

to a muscle weakened by undue stretching, partly to resist the action of the opposite group of muscles. A Z-shaped incision is made, the oblique ends now sliding over one another until the tendon is sufficiently shortened, when they are fixed by suture. But the method is not always a success, since the weak or paralysed muscle may stretch again.

Tendon-grafting.—To fill in a wide gap owing to the destruction of a portion of a tendon or the wide retraction of its end, a tendon from an animal or a slip from a neighbouring tendon may be grafted in with good results, especially in the case of a finger.

Tendon transference or transplantation has for its object the restoration, in part, of the functions of a paralysed muscle, or at least the prevention of a deformity by offering resistance to the action of opposing muscles. A paralysed muscle may be reinforced by uniting it with an active muscle of the same group, *e.g.*, the tibialis anticus with the extensor longus hallucis or with the extensor communis digitorum. Or a muscle's action may be reversed, thus the pronator radii teres may be detached and passed behind under the radius so as to become a supinator; or the action of a muscle may be varied, thus, the tendo achillis having been split, part may be united to the paralysed peronei tendons for the relief of talipes varus, or the reverse for talipes calcaneus. The sartorius has been made to reinforce the quadriceps, the trapezius to supplement the deltoid.

In carrying out such measures, strict aseptic precautions are necessary. For reinforcing, not only must the muscle be active as tested electrically, but the junction with the paralysed tendon must be at as small an angle as possible; the reinforcing tendon is slipped through a buttonhole opening made in the tendon to be reinforced and is fixed there by sutures.

The results so far have been generally that the patients have not regained much actual voluntary movement, but deformities have been arrested and instruments largely dispensed with.

Ossification of muscle may occur as the result of partial rupture or strain, as the *rider's bone*, or ossification of the adductors, occasionally met with in persons who ride a great deal; the *drill bone*, or ossification of the deltoid, in soldiers as the result of shouldering arms; and the ossification of the rectus femoris or pectoralis major.

Myositis ossificans is a progressive congenital affection, usually first manifested in boyhood, and seldom seen in females. Masses of bone develop in the muscles, chiefly those of the back, producing deformity, eventually impeding respiration and so causing death in about ten years. It is often associated with irregular epiphysial ossification, and with the absence or ill-development of the proximal phalanx of the thumb and great toe. It is believed that the connective tissue of the muscle undergoes ossification whilst the true muscle fibres atrophy, but the pathology of the disease is quite obscure, and no treatment is of avail.

Tumours.—*Primary* tumours are very rare, but nearly all the varieties of connective-tissue tumours have been met with. Spindle- or round-celled sarcomata occur; the former, from the sheath of muscle or tendon, may be of slow growth, but tend to recur *in situ* (recurrent fibroid tumour); the latter, growing within the sheath and replacing the belly of the muscle, are generally malignant. A cavernous angioma may also replace the belly of a muscle such as the gracilis, semi-tendinosus, semi-membranosus, deltoid. *Secondary* invasion of muscle is common, a periosteal sarcoma spreading out into muscles, a carcinoma of the breast invading the pectoral.

Treatment.—If the tumour is still confined to the muscle, the whole, from its origin to its insertion, must be excised; the rectus abdominis, the gracilis femoris are instances of muscles which have been thus treated. If the growth has spread beyond, wide excision or amputation high above the disease is needed.

DISEASES OF TENDON SHEATHS.

Simple teno-synovitis, or serous inflammation within the sheath of a tendon, is most frequently met with in the subacute form in sprains and from over-use, especially in the latter case in the tendons about the wrist, from hard rowing and the like. An elongated swelling forms in the course of the affected sheath, with pain on pressure and on movement, when there is a characteristic creaking sensation or friction-rub to be felt and heard. Less often it is rheumatic or gouty in origin. In the severe form redness and inflammatory induration of the skin occur. *Treatment.*—Rest on a pillow, with the application of lead lotion or glycerine and belladonna extract; in less acute cases, bandaging on a splint for a short time; in chronic cases, counter-irritation by iodine, and rest. As the inflammation subsides, gentle movements are necessary to avoid adhesions, and the hand must not be kept too long at rest, or forced movement under an anæsthetic will be needed.

Tuberculous teno-synovitis is primary, tubercles developing in the lining synovial membrane as in a joint. It sometimes follows on an injury, or is secondary by extension from joints or bones.

Hygroma, or ganglion, is a simple or compound cyst formed in connection with the sheath of a tendon, and is the result of teno-synovitis, either traumatic or tuberculous.

A *simple ganglion* is formed by the fusiform dilatation of the synovial sheath, by a transformation of synovial fringes, or by a pouch-like protrusion of the synovial lining between the fibres of the tendon sheath, the neck of the pouch remaining open or becoming obliterated. Ganglia are most common in the tendon sheaths about the wrist and ankle, forming smooth, globular, translucent, tense or semi-fluctuating swellings, moving a little transversely, whilst the tendon moves beneath or beside them. They vary in size from a pea to

a pigeon's egg, are seldom attended by pain unless in contact with a nerve-trunk, but give rise to a feeling of weakness in the wrist or fingers, of which the patient makes special complaint. When exposed, the cyst appears greyish, semi-translucent, and from the interior comes a clear inspissated synovial fluid like white of egg, or the contents may have undergone alteration, as in the case of the compound ganglion. The sac is found intimately connected with the sheath of a tendon, and the latter is exposed as the ganglion is dissected away. A simple ganglion is closely simulated by protrusions of synovial membrane from carpal or tarsal joints, which are distinguished by their deep and fixed attachment unconnected with a tendon sheath and the concomitant swelling of other parts of the synovial membrane.

Treatment—It may often be ruptured by pressure of the thumbs or a sharp blow, or may be punctured by a tenotome, the skin being drawn aside to make a valvular opening and the contents squeezed out. Afterwards firm pressure is applied. Some are thus cured, many relapse; a simple tuberculous ganglion may in this way be made compound. Generally the best treatment, and always if there is any sign of tubercle, is to dissect out the ganglion completely, sew up, and begin movement as soon as possible.

A *compound ganglion* is formed by the dilatation of the sheath of several tendons, and is usually a tuberculous process by extension of a simple teno-synovitis or ganglion. It is most common in the sheath of the flexor tendons above and below the annular ligament, forming a compound palmar ganglion, and more rarely is seen about the ankle or in the foot. The synovial membrane, as in joints, becomes thickened, pulpy, like a villous membrane; loose bodies, shaped like melon seeds, rice grains or poppy seeds, are found in the fluid, which may be clear like white of egg, or turbid, or caseous or chocolate-coloured from extravasated blood. The tubercle bacillus has also been found.

Signs.—A compound ganglion forms in the hand, as a doughy swelling in the palm and above the wrist, the swelling being constricted by the annular ligament; it may extend along the tendon sheath of the thumb and little finger. Fluctuation is obtained by pressing alternately above and below the ligament. It is most likely to be confused with a diffuse lipoma in the same situation, but the latter is very rare. A similar condition may be seen in front or to the inner side of the ankle. The joint movements are free, unless the compound ganglion is secondary to tuberculous arthritis.

Treatment.—It is most important that the disease should be treated by operation before caseation and suppuration take place, or the hand will be rendered useless and amputation may be necessary. A longitudinal incision is made, and the whole of the contents and diseased sheath cut, scraped, and washed away. The incision must be long enough to follow up all extensions, but it may be possible to avoid dividing the chief transverse fibres of the annular ligament.

Iodoform may be dusted in, or not; then the wound is completely sutured, and as soon as it has healed passive movements and massage are commenced. Recovery, with good or almost complete movement, may be obtained when the hand is not infected by septic germs.

Suppurative teno-synovitis.—*Thecal abscess.*—As an acute inflammation, this is the result of septic infection, either directly through a wound, or secondarily by extension from an ulcer or abscess. It is most common as a form of whitlow in the finger, *paronychia tendinosa;* in the foot it may be set up by a splinter, needle, etc. An acute effusion distends the sheath with pus, and unless this is quickly let out, the synovial folds carrying the blood-vessels to the tendon are destroyed and the tendon sloughs. At the same time there is a grave danger of extension, either along the tendon sheaths around the wrist or ankle, or to the small joints of the hand or foot, and through the periosteum to the bones, which necrose. The patient meanwhile suffers from septic absorption, and septicæmia and pyæmia may ensue (see *Diseases of Hand*).

Treatment.—A free incision is made into the tendon sheath as soon as possible, avoiding division of annular and other ligaments which retain the tendons; then the use of boric-acid fomentations or baths, after wiping out with a strong antiseptic. If the disease spreads, amputation may be called for.

Subacute suppurative teno-synovitis is usually tuberculous in origin (see *Compound ganglion*).

DISEASES OF FASCIÆ AND LIGAMENTS.

Relaxation.—As a result of strain and inflammation, there may be weakening of the ligaments of joints. The general treatment consists in rest in order to give the ligaments opportunity to contract, and in some circumstances hastening this by the careful application of the actual cautery.

Contracture.—The palmar fascia undergoes a peculiar primary change (see *Dupuytren's contraction*). The plantar fascia suffers from secondary contracture in connection with deformities of the foot; and so also contracture takes place of the ligaments of a joint when it is kept in a deformed position; the tensor fasciæ femoris shortens in the course of knock-knee. *Treatment.*—Division through an open incision, or, in simple cases where no injury is likely to arise, by subcutaneous tenotomy (see *Diseases of Extremities*).

DISEASES OF BURSÆ.

Bursæ, wherever situated, and whether existing naturally or formed adventitiously, are liable to become acutely or chronically inflamed.

Acute bursitis may occur spontaneously, but is generally excited by injury, or undue pressure as from constant kneeling. The inflammation comes on rather suddenly, the part appearing red, hot, and swollen. It is apt to terminate in suppuration, which if timely incisions are not made may become diffuse and phlegmonous. Evaporating lotions, an ice-bag or a few leeches may, if applied early, check the inflammation; but a free incision must be made as soon as there are signs of suppuration.

Chronic bursitis is very apt to occur in bursæ that are subjected to continued pressure or irritation, and may lead to several distinct conditions. Thus, 1. Bursæ may become simply enlarged and distended with serous effusions (*simple chronic bursitis*). In this state they form globular, fluctuating, often translucent, tense or flaccid swellings; their walls are but slightly thickened; and there is little or no heat or redness of the skin. 2. They may become enlarged, slightly thickened, and distended with a serous or blood-stained fluid containing small masses of fibrin resembling melon-seeds. This variety is believed to be tuberculous (*chronic tuberculous bursitis*). These melon-seed bodies may be formed from extravasated blood, fibrinous deposits, or detached portions of thickened synovial fringes, and their presence may sometimes be detected by the crackling sensation they give when the bursa is handled. Sometimes in place of, or together with, melon-seed bodies, fibrous cords are found stretching across the cavity of the bursa. 3. They may become enlarged and their walls greatly thickened by inflammatory infiltration and the deposit of fibrin in their interior (*chronic fibroid bursitis*). A small central cavity may remain, or they may be solid throughout. They then appear as firm, non-elastic, solid-feeling tumours, and when situated over the tuberosity of the ischium, or in front of the patella, may cause much inconvenience. 4. Their walls may become the seat of gummata (*syphilitic bursitis*). Hard masses in the walls of the bursa are felt, which later as the skin becomes involved present the characteristic features of breaking-down gummata, and later of tertiary ulcers. 5. Their walls may be infiltrated with urate of soda (*gouty bursitis*). They then present the signs of gouty deposits in other situations, and later of gouty ulcers.

Treatment.—When simply enlarged, painting with the liniment of iodine, or strapping, will sometimes disperse them. If this fails, they may be punctured, the fluid evacuated, and firm pressure applied. The bursæ when containing melon-seed bodies, and suppurating or tuberculous, may be laid open, thoroughly scraped, and plugged with iodoform gauze; but generally, and always when greatly thickened or solid, they must be dissected out. In the syphilitic and gouty the remedies for these affections are required.

Varieties of bursitis and of bursal enlargement (Fig. 146).—*In front of the knee*: (1) The prepatellar bursa. The bursa lies over the

lower half of the patella and the upper part of the ligament, and when enlarged is called the house-maid's knee, being generally due to kneeling. It forms a swelling in front of the patella and of the knee-joint, and the general account above especially applies to it. It may increase to the size of a large orange. In all except very recent cases, excision is the best treatment, and this may be done by a median incision or by raising a semilunar flap in any direction. In dissecting it out, the edge of the knife must be kept against the tumour to avoid the capsule of the knee-joint. When thick-walled, there is no difficulty; when thin-walled, a finger in the cavity of the bursa will serve as a

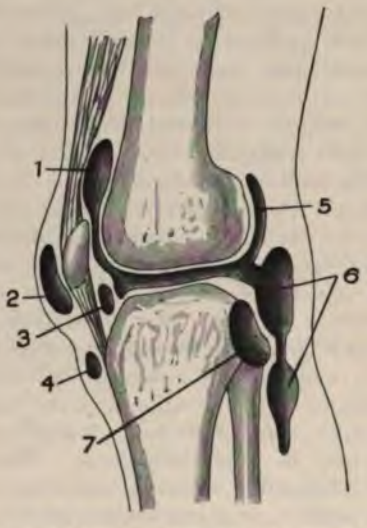


FIG. 146.—Bursæ and cysts about the knee. 1. Subcrureus bursa communicating with joint. 2. Prepatellar bursa. 3. Bursa beneath the ligamentum patellæ. 4. Bursa over the tubercle of the tibia. 5. Synovial cavity of knee-joint distended behind the condyles. 6. The same enlarging and spreading downwards into the calf (Morrant Baker's cyst). 7. Semi-membranosus bursa.

guide. If allowed to suppurate, pus bursts into the subcutaneous tissue to either side of the knee and spreads up the thigh. Only when the posterior wall ulcerates through and the patella necroses, does the suppuration tend to spread to the knee-joint.

(2) The bursa over the tubercle of the tibia enlarges, and becomes thick-walled up to the size of a walnut, and then excision is generally required.

(3) The bursa beneath the ligamentum patellæ enlarges and bulges on either side. Counter-irritation generally suffices to reduce it.

(4) The subcrureus bursa is usually a portion of the knee-joint, but may be shut off from the joint by adhesions, when it may be aspirated or incised from the outer side.

Behind the knee: (1) The semi-membranosus bursa as it enlarges forms an elastic ovoid swelling in the popliteal space, not pulsating, tense when the knee is straightened, flaccid or hardly to be felt when flexed. It is commonest in young women and men, and is not connected in its early stages with the joint, which is healthy. It must be distinguished from a cyst formed by bulging of the synovial membrane of the joint (*Morrant Baker's cysts*), in which there is generally some chronic arthritis. The semi-membranosus bursa in its later stages frequently communicates with the joint, and both it and a joint-cyst burrow downwards among the muscles of the calf forming intermuscular cysts. Suppuration ultimately supervenes. *Treatment.*—Both the bursa and joint-cyst should be carefully dissected out, and not punctured or allowed to burrow among the muscles and suppurate. If the communication with the knee is but narrow, a ligature or suture may be used to close it.

The *olecranon bursa* is frequently the seat of inflammation, due to injury simple or septic; also to long resting on the elbow when it becomes thickened, hence the term miner's bursa. From septic bursitis pus spreads subcutaneously round the joint and downwards into the forearm, the olecranon becomes necrosed, and the elbow-joint involved. *Treatment.*—Cold lotions for simple, an incision and scraping for septic inflammation, and excision when the walls are thickened.

The *ischial bursa.*—Its enlargement, often bilateral, was common in weavers, who slid on their seat when throwing the shuttle; it may also be seen in coachmen and boatmen. It forms a deep-seated swelling in the buttock attached to the tuberosity. If suppuration follows, the whole buttock may become indurated and the ischial tuberosity necrosed. *Treatment.*—Early excision.

The *bursa over the great trochanter* may be inflamed by resting on it and by the rubbing of a splint. *Treatment.*—Excision.

The *psoas bursa*, in front of the hip-joint, is enlarged occasionally when the hip is affected with osteo-arthritis. It forms a firm swelling behind and to the outer side of the vessels, relaxing when the hip is flexed, the hip not presenting any signs of acute disease. *Treatment.*—Rest or, failing this, a careful incision outside the vessels and the filling of the cavity with gauze whilst the hip is fixed in extension.

The *deltoid bursa* enlarges generally under similar circumstances in connection with osteo-arthritis, and may be *treated* in like manner.

The *bursa beneath the tendo Achillis* may enlarge from long marching, and yield to rest and counter-irritation. Adventitious bursæ form over points of bone, as the *rider's bursa* over the inner condyle; *under corns* on the metatarso-phalangeal prominences, as *bunions*; and on the outer side of the foot in talipes varus. For these excision is required when rest and counter-irritation have failed to cure.

DISEASES OF THE ARTERIES.

Arteritis or inflammation of the arteries may be *acute* or *chronic*.

Acute arteritis was formerly thought to be of frequent occurrence as an *idiopathic* affection, but as such it is now known not to exist. *Acute traumatic arteritis*, however, is very common, occurring as it does in the *simple* or *plastic* form in the process of healing of an artery after injury or ligature (see *Healing of Arteries*), or from the presence of a non-infective thrombus. As an *infective, suppurative* affection it is occasionally met with as the result of the application of a septic ligature, the extension of infective inflammation to an artery from the surrounding tissues, or as the result of the presence of an infective embolus brought by the blood-stream from a like inflammation of a distant part, as the heart in ulcerative endocarditis. It may lead to the softening and giving way of the arterial walls, and, unless a clot forms above and below, to secondary hæmorrhage; whilst when due to an embolus it may by weakening or causing rupture of the wall give rise to a diffuse aneurysm. It is believed to be the chief cause of spontaneous aneurysm in children.

Chronic arteritis, familiarly known as *atheroma*, mainly affects the deeper layers of the intima, not, as a rule, the other coats. It is the commonest disease of the arteries, and to some extent is generally present in persons over forty. It is most frequent in the aorta and large vessels, that is, in those containing the greatest amount of yellow elastic tissue, and is more often met with in the arteries of the lower than in those of the upper limb. Patches of atheroma are particularly common at spots where a large vessel bifurcates or gives off a large branch, since in such situations the vascular tension is increased.

Causes.—Mechanical strain or vascular tension is looked upon as the most frequent *exciting* cause. Thus atheroma is attributed to—1, occupations necessitating severe and prolonged exertion; 2, the abuse of alcohol, which produces an increased and forcible action of the heart; 3, chronic Bright's disease, in which the blood pressure, in consequence of capillary fibrosis or spasm of the arterioles, is increased; 4, plethora, in which the arterial tension is also raised; 5, syphilis, which is attended by fibroid change in the small vessels and consequent increased vascular tension; and 6, gout, in that it may produce Bright's disease. In addition, however, to the increased vascular tension, to which the above-mentioned conditions may give rise, gout, syphilis, and alcohol may also lead to primary degenerative changes in the coats of the arteries in common with the degenerations they induce in the tissues generally throughout the body, and hence, together with advancing age, and the male sex, men being more exposed to mechanical strains

than women, may be looked upon as *predisposing* as well as exciting causes.

Pathology.—Arteritis begins as a small-round-cell infiltration of the deeper layers of the intima—those next the muscular coat. This gives rise to characteristic greyish-white, slightly-elevated, tough, semi-gelatinous patches on the inner surface of the vessel. The patches, which frequently begin around the entrance of small lateral branches, increase by their edges, and by coalescing with other patches, produce extensive tracts of the disease (Fig. 147). The inflammatory infiltration in consequence of the absence of new vessels, may undergo—1, fatty; 2, calcareous; or 3, fibroid degeneration.

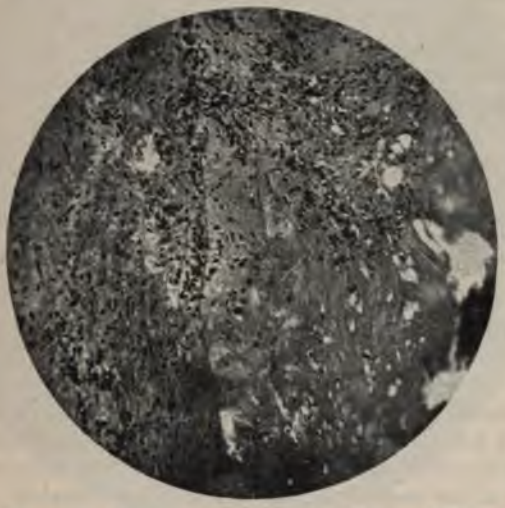


Fig. 147.—Atheromatous degeneration in an artery. Photograph of a section. To the left is the arterial wall infiltrated by inflammatory cells, to the right is the atheromatous degeneration breaking down into an ulcer.

1. The patches formerly grey become yellowish-white, breaking down into a cheesy mass or completely liquefying into a puriform fluid consisting of fatty débris, cholesterine-crystals, and minute oil-drops. The layers of the intima next the blood are at first continued unbroken over the fatty patch, which is then called an *atheromatous abscess.* These layers, however, may subsequently give way, leaving the softened and fatty mass in contact with the blood (the *atheromatous ulcer*). Portions of the fatty material may now be washed away by the blood stream and become lodged in some of the smaller arteries and capillaries, where they may not however, do any harm, as the emboli are non-infective. At times, however, a larger vessel may become plugged, when gangrene may ensue. As the atheromatous material is washed away by the blood,

fibroid thickening of the external coat and sheath of the artery takes place opposite the base of the ulcer, so preventing perforation of the artery; but as the new tissue is very inelastic it is liable to yield to the pressure of the blood and an aneurysm occur. 2. Instead of the patch undergoing fatty softening, lime salts may be deposited in it. This *secondary calcification* must be distinguished from the *primary calcification* to be shortly mentioned. The intima may be continued over the calcareous patch, or it may break away, leaving it exposed to the blood-current, thus constituting a nidus for the deposition of fibrin and the formation of a thrombus, portions of which again in their turn may be washed away by the blood and form emboli. 3. The small-cell infiltration in the inflamed patch instead of undergoing either of the former changes may advance to the production of fibrous tissue, and dense *fibroid* thickening result.

The effects of chronic arteritis.—1. The artery may become dilated, elongated, and tortuous; 2, it may yield at the atheromatous patch, producing an aneurysm; and 3, it may rupture under violence. In addition to the above effects depending upon the loss of elasticity of the vessel, thrombosis and embolism may occur as already stated, and give rise to gangrene, aneurysm, or rupture.

Signs.—Except in the superficial vessels, where atheroma is productive of rigidity and a tortuous condition of the artery, it gives no special evidence of its presence.

Syphilitic arteritis is the term applied to a fibroid change occurring chiefly in the smaller arteries during the later stages of syphilis. It is most common in the arteries of the brain. The change consists in an extensive infiltration of small round cells, which later become developed into an imperfect fibrous tissue. The inner coat is chiefly affected, and becomes greatly thickened, so that the lumen of the vessel is almost or entirely obliterated The outer coat is likewise implicated, but to a less extent, while the muscular coat either escapes, or is merely encroached upon by the cells infiltrating the inner coat. The disease is very chronic, and may terminate in thrombosis, or may lead to the formation of an aneurysm.

Endarteritis or obliterative arteritis, so called, is a rare disease, characterised by great pain spreading up the course of the artery, loss of pulse in the vessel, and often gangrene of the part supplied by it. Its pathology is now known to consist in a thickening of the endothelium and sub-endothelial layers of the intima, but the cause, although often attributed to syphilis, is unknown (Fig. 148). In several cases observed for long periods the disease has undergone arrest.

Primary degeneration of arteries.—We have already seen that fatty, calcareous, and fibroid degeneration may follow chronic endarteritis. These changes may, however, occur as primary affections, and may next be considered.

Primary fatty degeneration begins in the superficial layers of the intima, immediately under the endothelium. It takes the form of yellowish-white patches, very slightly projecting into the vessel. The patches can be readily stripped off from the deeper layers, which when thus exposed are found healthy; whereas, in atheroma, it is the deeper layers which are the seat of the disease. The disease is attended with no signs, and is of little practical interest.

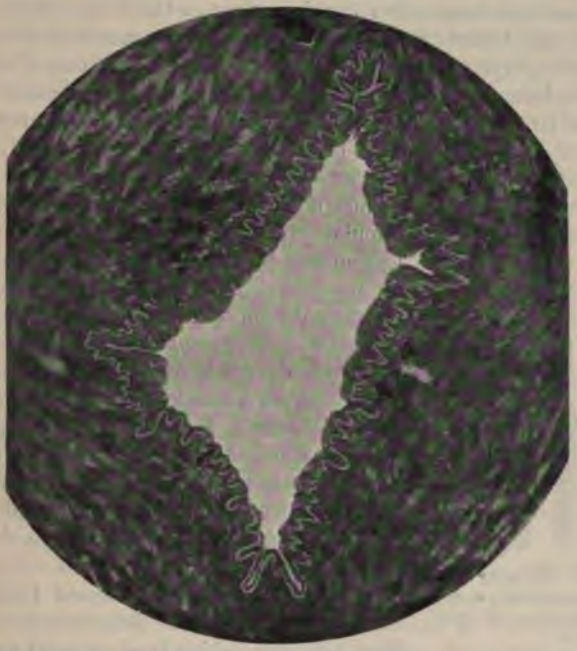


FIG. 148.—Endarteritis obliterans. Photograph of a section of the tibial artery. The endothelial and sub-endothelial layers are thickened, and the inflammation has spread, especially at one point, through the elastic lamina. From a non-syphilitic young man affected in three of his limbs, one leg becoming gangrenous.

Primary calcification is of more importance. It should be distinguished from calcification occurring as a secondary change in arteritis. Primary calcification begins in the circular muscular fibres of the middle coat, and is more common in the smaller than in the larger arteries, and in those of the lower than in those of the upper extremity. It is a disease of advancing age, and is a frequent cause of senile gangrene in that the arteries are converted into rigid tubes and the circulation through them is in consequence greatly impeded. Thrombosis, moreover, is very liable to occur, but aneurysm is exceedingly *uncommon*, since the arteries are rigid and do not yield to the blood current as do arteries weakened by

atheroma. In primary calcification the lime salts are deposited in the circular muscle fibres in the form of rings (Fig. 149) instead of in irregular patches as in secondary calcification following atheroma.

Embolism.—An *embolus* is a plug formed by some solid body in a vessel, having been brought there by the blood stream in the arteries, veins, or lymphatics, generally in the usual course of the stream, but possibly retrograde under certain circumstances. A simple embolus is composed of fibrin detached from the cardiac valves, or from some other rough surface in the large arteries, and is due to the disturbance of a thrombus, as the result of pressure or external injury. It tends to lodge at the bifurcation of an artery into its branches, where its effects depend upon whether the circulation to the part supplied by the blocked vessel is quite cut off by the plug filling the artery, and whether the anastomotic blood supply can afford a sufficient circulation to the part below. The circulation being cut off, the results may be loss of function, paralysis, dyspnœa, failure of nutrition, gangrene, cerebral softening, or coagulation necrosis. A septic embolus carries with it pyogenic organisms, and may lodge in a large artery, but as often breaks up into small particles which are arrested in the capillaries. In some cases the plugging of the capillaries seems to be nearly wholly by organisms with practically no fibrin. The results are septic inflammation and abscess, with a tendency to hæmorrhage from the giving way of the vessel walls.

Fig. 149.—Primary calcification of arteries. (St. Bartholomew's Hospital Museum.)

Metastatic emboli are formed by particles composed of the cells detached from malignant tumours, which being carried away may lodge in lymphatics or glands, or reaching the main blood stream be carried to some distant part or organ where the cells begin to grow and form a secondary tumour, the counterpart of the primary one.

Fat embolism is a rare complication of fracture, and *air embolism* of injuries in the neck (see *Fractures* and *Air in Veins*).

ANEURYSM.

An aneurysm is a tumour containing blood and communicating with the interior of an artery. Aneurysms may be divided into two main classes, the *spontaneous*, which are the result of disease of the arterial walls, and the *traumatic*, which are due to a direct injury of the artery and extravasation of blood into the tissues. Here the spontaneous will especially receive attention. The traumatic are described under *Injuries of Arteries* (p. 276).

Spontaneous aneurysm. — *Cause.* — Aneurysms are most common at that age when the coats of the arteries are liable to be weakened by disease whilst the muscular system is still vigorous, and are chiefly met with among those whose occupations subject them to sudden or irregular strains. Hence the frequency with which they occur in soldiers, sailors, and the labouring classes, and in men rather than in women. All surgical aneurysms are rare in women, only in the case of the carotid does the frequency in the female approach that of the male. The chief *predisposing causes* are—1, *atheroma*, whereby the coats of the artery are softened and unable to resist an increased expansile pressure of the blood; and 2, *embolism*, which may lead to inflammatory changes, and consequent weakening of the arterial walls immediately above the embolus. Thus the conditions which induce atheroma and embolism may also be considered as predisposing causes of aneurysm. Of these, however, syphilis, the abuse of alcohol, continued vascular strain, and ulcerative endocarditis may be especially mentioned. Syphilis is by far the most common cause of aneurysm in women. The *exciting causes* are such as produce the rupture or yielding of the diseased coats, either (*a*) by direct mechanical violence, or (*b*) by increased blood pressure in the vessel owing to violent and sudden action of the heart and obstruction by muscular contraction of the capillary flow. Hence blows or strains, mental emotion, and violent and sudden exertion of all kinds may be mentioned as exciting causes.

Process of formation.—An aneurysm may be formed in several ways:—1. By the simple dilatation of a diseased portion of an artery due to the yielding of the softened coats to the expansile force of the blood current. 2. By the giving way of the internal and middle coats at the diseased spot, and the yielding of the external coat to the force of the blood. This is the commonest way in which an aneurysm is formed. The elastic fibres of the internal coat as the result of the atheroma soften and break down, the middle coat gives way, and the external coat, unable to resist the blood pressure, is bulged out, forming the sac of the aneurysm. 3. By the giving way of all the coats at the diseased spot and escape of the blood into the tissues which become condensed around it to form a sac. 4. By the giving way of the external and middle coats, and the protrusion of the internal coat through them (very rare); and 5. By the giving way of the internal and part of the middle coats, and extravasation of the blood between the layers of the middle coat.

Structure of an aneurysm.—An aneurysm consists of a sac and its contents. *The sac* may consist—(1) of all the coats of the artery, Fig. 150, A and B; (2) of the external coat only, Fig. 150, C; (3) of condensed tissues external to the artery, Fig. 150, F; (4) of the internal coat only (very rare), Fig. 150, D; (5) of the separated

layers of the middle coat, between which the blood has been forced, with the external and internal coats on either side (*dissecting aneurysm*), Fig. 150, E. The practical point, however, to be borne in mind, is that it is only while the aneurysm is small, and then by dissection alone, that these distinctions can be made; and that as the aneurysm increases in size the tissues around become condensed and blended with the sac, which may finally be formed almost or entirely of these tissues and of new fibrous tissue produced by the chronic inflammatory process set up in them. *The contents of the sac.*—When an aneurysm is first formed, the sac only contains fluid blood; fibrin, however, is gradually deposited from the blood in concentric layers upon the internal surface of the sac, so that after it has existed some time, the contents are partly solid laminated fibrin, and partly coagulated and fluid blood. Next the wall of the sac the fibrin is laminated, firm and compressed, and of a yellowish-white colour; but towards the mouth of the sac it becomes softer and moister, and of a reddish colour; whilst that in contact with

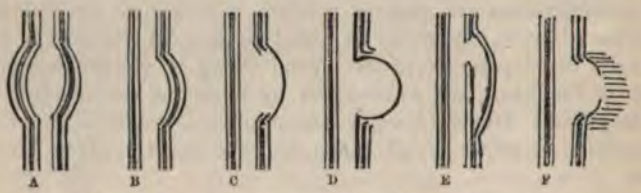


FIG. 150.—Diagram illustrating the structure of an aneurysm.

the fluid blood merely resembles ordinary blood coagulum. In an aneurysm that has been cured, the whole sac will generally be found thus filled with laminated fibrin (*active clot*) of a pale buff-colour from removal of the blood pigment, and has been aptly likened to the appearance presented by the section of an onion (Fig. 151). Where the cure has taken place in a few hours, it is probable that the greater part of the material filling the sac is merely blood coagulum (*passive clot*), dark blue from deoxygenated hæmoglobin, as in such instances the time would probably be too short for fibrin to be deposited.

Classification.—Spontaneous aneurysms may be divided into the fusiform, the sacculated, and the dissecting.

1. *A fusiform aneurysm* is a dilatation of the whole circumference of a portion of an artery. The sac consists of all three coats, and is continuous with the lumen of the artery at each end (Fig. 150, A). The dilated portion of the artery is also elongated, as is well seen in aneurysms of the arch of the aorta, where, in consequence of such elongation, the three primary branches are much further apart than normal (Fig. 151). Fusiform aneurysms are most common in arteries that contain much yellow elastic

tissue, as the aorta and its primary branches and the contiguous portions of the iliac and femoral arteries. They often attain a large size, and after they have existed some time frequently become sacculated from the unequal yielding of their walls. The walls themselves, though sometimes thinned, are more often thickened, and are highly atheromatous. Laminated fibrin is seldom found in them, as the circulation does not as a rule become sufficiently retarded to allow of its deposition.

2. *A sacculated aneurysm* is one in which dilatation occurs in part of the circumference of the artery only (Fig. 150, B, C, and D). It may consist of all three coats; but much more often the internal and middle coats give way, and it is formed of only the external

FIG. 151.—Laminated appearance of the clot filling a consolidated aneurysm of the arch of the aorta. (St. Bartholomew's Hospital Museum.)

coat, or after it has existed some time, chiefly of fibrous tissue formed by the inflammatory condensation of the tissue around. According as all three coats are or are not present, the aneurysm was formerly spoken of as *true* or *false*. As, however, it is only the smallest aneurysms that can consist of all three coats, the true aneurysm could hardly be said ever to occur, and all sacculated aneurysms were then called false—the absurdity of which is self-evident. As these aneurysms increase in size, the sac comes to consist almost entirely of the tissues around. Whilst they are still enclosed by one of the coats of the artery, they are sometimes called *circumscribed*, and after all the coats have given way, *consecutive or diffused* (Fig. 150, F). As the term diffused, however, is sometimes applied to a leaking or ruptured aneurysm, it had better be discontinued. Nearly all sacculated aneurysms when they have

loss of pulsation and bruit, rapid increase in the size of the swelling, œdema, coldness, and cessation of the pulse in the parts below, followed by increasing syncope from loss of blood, or if death does not soon occur, by gangrene. 4. Rupture externally is very rare; the signs are evident.

Diagnosis.—An aneurysm may have to be diagnosed from simple dilatation of an artery, an abscess or tumour over an artery, a pulsatile tumour of bone, and enlargement of the thyroid gland. In a *simple dilatation*, there is an absence of bruit. In an *abscess or tumour over an artery*, the pulsation is not expansile, there is no bruit unless the vessel is compressed, and the swelling is not emptied or made less tense on compressing the artery above. A *tumour* can often be lifted from the vessel. In the case of an *abscess*, there will probably be a history or signs of previous inflammation. In a *tumour raising an artery over it*, the pulsation is only felt in the course of the artery, and there is no expansile pulsation in the swelling. In a *pulsatile tumour of bone*, the pulsation is not equally expansile all over; and although pulsation is stopped on compressing the artery above, the swelling does not become smaller like an aneurysm, or refill on removal of the pressure in two or three beats of the heart. The tumour may not be quite in the line of the artery. Portions of expanded bone may also be felt in parts of the tumour, and there may be glandular enlargement and other signs of malignancy. From an *enlarged thyroid gland*, a carotid aneurysm may be distinguished by the gland moving with the larynx on deglutition. In very rare instances there may be no pulsation in an aneurysm. We have met with such a case ourselves. The diagnosis from a cystic or a solid tumour is then very difficult if not impossible without an exploratory incision.

Treatment.—In no disease, perhaps, has an accurate knowledge of its pathology done more to ensure success in treatment than in aneurysm. The older surgeons, believing that the clot possessed vicious properties, directed their efforts to the emptying of the sac; and it was not until the fact became fully recognised that the natural method of obliterating an aneurysm was by the sac filling with organisable clot, that the lamentable results attending the treatment of aneurysm in olden times gave place to the successes of modern surgery. Thus by aiding or promoting the formation of laminated clot by means of rest, low diet, recumbency, and medicines, the surgeon endeavours to lessen the force of the blood-current through the sac; whilst by compression or ligature of the artery between the aneurysm and the heart his aim is to cut off the direct flow of blood through the artery leading to the aneurysm, so that only a slow stream enters the sac by the distal end and anastomosing channels. By the use of the distal ligature, the method of spontaneous cure that is sometimes brought about by the plugging of the artery beyond the aneurysm is followed. Excision may be said in a

sense to adopt the occasional method of spontaneous cure seen in the sloughing away of the whole aneurysm without the dangers from intercurrent hæmorrhage. The treatment of aneurysm, therefore, may be divided into the medical or general, and the surgical or local.

Medical treatment.—Both internal and external aneurysms have been cured by medical treatment alone. Indeed, in some forms of internal aneurysm, it is the only means at our command. In external aneurysms, however, local treatment in addition is nearly always expedient or necessary. Absolute rest, both bodily and mental, should be enjoined; the patient must lie in bed, and must not move for any purpose.

The dieting of such patients with the object of favouring coagulation is a matter about which opinions greatly vary. Extreme restrictions in diet, such as that advised by Mr. Tufnell, are not now in much favour. A patient who is about to be treated surgically should certainly not be lowered by it. The ordinary medical regimen should be prolonged rest, a fish or similar light diet with as little fluid as can conveniently be taken, and a regular action of the bowels. Tufnell's diet is a heroic measure, which, if really carried out, is a very severe trial to the patient. It consists of bread and butter, 4 ozs.; meat, 3 ozs.; potatoes, 3 ozs.; fluid, 8 ozs., in the twenty-four hours. Frequent bleedings and strong purgation are useless. The judicious use of iodide of potassium is indicated in syphilitic cases, and it may relieve excess of pulse-tension, but the patient must not be weakened by large doses if an operation is in prospect, indeed some anæmic patients require iron and a stimulating diet. *Gelatin injections* subcutaneously have been attended with but little success. 150 to 200 ccm. of sterilised artificial serum containing 1·5 to 3 grm. of gelatin is injected subcutaneously into the back with careful asepsis, and may be repeated at the end of a week. Only slight febrile reaction should follow. But the treatment has been responsible for tetanus, the gelatine having been doubtless derived from an infected horse.

Surgical treatment.—In suitable cases of external aneurysm pressure, when it can be applied between the aneurysm and the heart, may first be tried, aided in some situations by the method of flexion. But these failing, or appearing unsuitable, the artery should be tied, if practicable, on the proximal side, or the whole aneurysm may be, under certain circumstances, excised. Where pressure or ligature cannot be used on the proximal side, as, for instance, in aneurysms at the root of the neck, it becomes a question whether we should try distal pressure or ligature, scratching the wall with needles (*Macewen's method*), the introduction of wire, electrolysis, or fall back on medical means alone. In some varieties of traumatic aneurysm, and in some other aneurysms as gluteal, it may even be expedient to resort to the old method of opening the sac, turning out the clot, and securing both ends of the bleeding vessel by

ligature. Each of these methods requires discussion. Before resorting to surgical methods, however, the circulation through the aneurysm should have been previously quieted as much as possible by rest, recumbency, restriction of the diet, and regulation of the bowels. Where the aneurysm is on an artery of the lower extremity, any embarrassment of the venous circulation and consequent œdema that may be present should be lessened or removed by elevating and lightly bandaging the limb.

Pressure.—This method of treating aneurysm was known to the older surgeons, but in consequence of their efforts being directed either to the emptying of the sac by direct pressure upon it, or to the obliteration of the artery leading to it by adhesive inflammation, it was attended with such unfavourable results that it fell into disuse. To the Dublin surgeons, who recognised the fact that it was not necessary to obliterate the artery in order to cause consolidation of the aneurysm, is due in chief part the credit of reviving treatment by pressure. The object of pressure as now employed is to produce consolidation of the aneurysm by the formation of either a laminated or an ordinary coagulum. The methods of bringing this about may be considered under 1, direct pressure on the aneurysm; and 2, indirect pressure, either on the artery above, on the artery below, or on both simultaneously.

1. *Direct pressure* is now seldom used, except in as far as flexion may be considered as in part a method of direct pressure, although several successful cases have of late been reported. It will not receive further notice.

2. *Indirect pressure*, whether applied to the artery above, the artery below, or to both at the same time, may be considered under the heads of (*a*) Digital pressure. (*b*) Instrumental pressure. (*c*) Pressure by Esmarch's bandage. (*d*) Pressure by flexion of the limb.

(*a*) *Digital pressure*, where it can be applied to the artery on the proximal side at some distance from the sac, is a safe method of treating an aneurysm; and it is the one which may first be tried, if skilled assistants can be obtained. There are some surgeons, however, who, now that the healing of the wound for the ligature of an artery can practically be assured by the first intention, prefer ligature to pressure as the more certain method. The advantages claimed for digital pressure are—1, that it causes less pain than other forms of pressure; 2, that the artery can be compressed with little or no interference with the venous circulation; 3, that it is less liable to injure the tissues; and 4, that in common with other methods of pressure, it does not expose the patient to the dangers of an open wound. Pressure-treatment requires a relay of intelligent assistants, acting in pairs and alternately compressing the artery for about ten minutes at a time. Whilst one presses the artery, the other should have his hand on the aneurysm, to ascertain if pulsation is being properly controlled. The fingers of the one assistant

should not be removed till the other has taken his place, as the artery must on no account escape compression for a single moment. The pressure of the fingers may be aided by a shot-bag, and the spot at which pressure is applied may be slightly varied from time to time. Opinions differ as to whether the circulation should be completely, or only partially, stopped through the artery, and whether the pressure should be continued both day and night, or only during the day. Aneurysms have been cured by digital pressure in a few hours, but some days are usually necessary; and to obtain success, much care and attention to detail is required.

(*b*) *Instrumental pressure* may be applied so as only partially to control the circulation through the artery, and thus induce the gradual obliteration of the aneurysm by the deposit of laminated fibrin in the sac (*slow pressure*); or it may be applied so as to completely control the flow of blood through the vessel, and induce

Fig. 156.—De Carte's tourniquet.

Fig. 157.—Lister's abdominal tourniquet.

Fig. 158.—Skey's tourniquet.

rapid coagulation in the sac (*rapid pressure*). The latter method can only be done under an anæsthetic, but has been attended with some brilliant results, especially in cases of abdominal aneurysm. As a rule for external aneurysms, however, the milder measures will suffice, and it is a question if these fail whether it is not better treatment to ligature the artery than subject the patient to further attempts at cure by rapid pressure. Both kinds of pressure may be applied by one or other of the many forms of compressors and tourniquets which have been invented for the purpose (Figs. 156, 157, and 158). It is better, when possible, to apply the pressure to one artery, though slightly varying its position, than to change from one artery to another, as from the superficial to the common femoral, since by so doing different sets of anastomosing arteries are enlarged, and the collateral circulation may become too free.

Cases unsuitable for pressure.—1. Where the aneurysm is of very large size, or is rapidly increasing. 2. Where the sac is thin, contains but little fibrin, and appears likely soon to burst. 3. Where

there is much œdema from venous obstruction. 4. Where the patient is of an irritable disposition, is intolerant of pain, or has been addicted to the abuse of alcohol. It is considered by some that even if pressure fails good may have been done by causing a deposit of fibrin in the sac, and by enlarging the collateral vessels. By others these advantages are thought to be outweighed by the irritation and disappointment to the patient of failure, and the bruising and injury of the tissues at the situation where the artery will have to be tied. Moreover the enlargement of the collateral vessels may endanger the subsequent success of the ligature by leading to recurrent pulsation in the sac.

(*c*) *Pressure by Esmarch's bandage* (*Reid's method*) aims at simultaneously compressing the artery above and below the aneurysm, and thus causing the blood contained in both the aneurysm and the artery to coagulate. The elastic bandage, in the case of popliteal aneurysm in which this method of compression has most often been used, should be evenly applied from the foot as far as the aneurysm; a turn should be then made over the tumour, so as only lightly, if at all, to compress the sac, and the bandaging then continued firmly half-way up the thigh. The bandage should be kept on for an hour to an hour and a half. The elastic cord should not be used at all. On removing the bandage digital pressure should be kept up on the main artery from thirty-six to forty-eight hours, so as to control the circulation and prevent the clot, while still soft, from being washed out of the artery and sac. The patient must be placed under an anæsthetic during the use of the bandage, as it causes great pain. Many cases have been cured by this method; but on the other hand there have been many failures, and it is far from being unattended with danger. Thus, gangrene of the limb and rupture of the sac have ensued, and aneurysms of internal arteries have been produced apparently by the prolonged increase of blood-pressure in the rest of the arterial system.

(*d*) *Pressure by flexion* (*Hart's method*) consists in flexing the limb so as to compress the artery by the aneurysm in imitation of that form of spontaneous cure which is brought about by the pressure of the aneurysm itself on the artery above and below. It is obviously applicable to aneurysms in but very few situations, and has been most successful in those of the popliteal artery. It may be used either alone, or in conjunction with digital or other pressure, or with medical treatment. This treatment causes much pain, and can seldom be endured.

Ligature, like pressure, is a very old method of treatment, but to Anel and John Hunter is due the credit of having placed it on a scientific basis. The older surgeons laid open the sac and turned out the clots, and endeavoured to staunch the hæmorrhage by ligaturing the artery above and below the aneurysm. Antyllus, it

is true, applied his ligatures before opening the sac; but it was not until centuries afterwards that Anel recognised the fact that it was unnecessary to open the sac at all, and tied the artery immediately above the aneurysm. Many years later Hunter perceived that the more or less complete stoppage of the circulation obtained by Anel's method was not necessary, and that the ligature of the artery close to the sac was attended with the risk of secondary hæmorrhage and inflammation of the sac. He therefore applied his ligature at a distance from the aneurysm, where he believed moreover that the artery was likely to be in a healthier condition. For aneurysms so situated that a ligature cannot be placed on the cardiac side, Brasdor proposed tying the trunk of the artery on the distal side of the aneurysm; whilst Wardrop suggested tying one or two of the terminal branches of the artery on the distal side of the aneurysm where neither Brasdor's operation nor the proximal ligature was applicable. Hence ligature for aneurysm may be applied (Fig. 159), 1. ON THE PROXIMAL SIDE of the aneurysm either at a distance (*Hunter's method*) or immediately above it (*Anel's method*). 2. ON THE DISTAL SIDE of the aneurysm, either to the main trunk (*Brasdor's method*), or to one or more of the main branches (*Wardrop's method*). 3. IMMEDIATELY ABOVE AND BELOW the aneurysm, either opening the sac (*the old operation*), or without opening the sac (*Antyllus's method*).

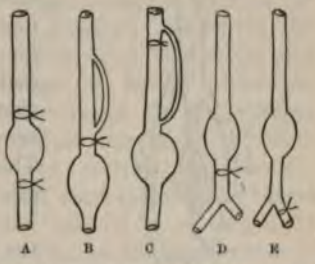


FIG. 159.—Different positions of ligature for aneurysm. A. Antyllus's method; B. Anel's; C. Hunter's; D. Brasdor's; and E. Wardrop's.

1. **The proximal ligature.**

A. **Hunter's method.**—This operation, when applicable, was until recently the one almost universally adopted. The chief merits claimed for it are—1. That the artery at the spot selected for ligature is not only more likely to be healthy, but is also more easily tied than the artery in close proximity to the sac, in which latter situation, moreover, its anatomical relations are liable to be disturbed by the aneurysm. 2. That the sac is not interfered with, and hence is less likely to become inflamed and suppurate; and 3. That as several branches will probably be given off between the ligature and the aneurysm, the circulation through the sac, though lessened, will not be completely arrested, and the clot is therefore more likely to have a laminated, and hence a permanent character. The disadvantages attending it are—1. That large collateral branches may carry the blood into the artery between the ligature and the aneurysm, and so lead to recurrent pulsation in the sac and further enlargement. 2. That gangrene is liable to occur in consequence of the blood having to pass through two sets of collateral vessels before it

reaches the parts beyond the sac. These risks seem to some surgeons to outbalance the advantage claimed for the method, and Anel's operation is by them substituted for it (see *Anel's operation*, p. 396).

Effects of the proximal ligature.—After the successful application of a ligature by the Hunterian method, the pulsation in the aneurysm immediately ceases, and for a time the circulation through the limb is diminished; hence the temperature becomes lower and the surface pale. Soon, however, the collateral circulation becomes established, and a faint pulsation may be felt again in the aneurysm; but this recurrent pulsation usually grows less from day to day, and shortly ceases, and the aneurysm slowly shrinks and is finally absorbed, or remains as a small, hard, fibrous mass. The artery leading to the aneurysm may remain pervious, but it more frequently becomes obliterated as far as the first collateral branch above and below the sac. The artery on either side of the ligature also becomes obliterated as far as the first collateral branch. This condition of an aneurysm and artery after ligature is seen in the accompanying diagram (Fig. 160). The blood passes the ligature by the collateral channels; re-enters the artery below; passes the obstruction where the artery is closed at the seat of the aneurysm, also by collateral channels; and then again enters the main artery.

FIG. 160.—Diagram to show the condition of the artery and aneurysm after the Hunterian ligature, and the establishment of the collateral circulation. The arrows indicate the direction of the blood current.

Treatment after ligature.—The limb should be completely swathed in the cotton-wool and flannel bandages (which, before the operation, should have already been carried up as far as the seat of the ligature), and kept at perfect rest. In the case of popliteal aneurysm, the limb should be slightly raised on a pillow, and placed on its outer side, with the knee a little flexed, care being taken that no pressure is made on the heel, malleoli, or other points of bone, for fear of local sloughing. If the weather is at all cold, hot bottles should be applied, near, but not in contact with, the limb. The patient must be kept in bed till the aneurysm is thoroughly consolidated, and the operation wound has healed.

The dangers of ligatures.—These are (*a*) connected with the wound: suppuration followed by secondary hæmorrhage, phlebitis; (*b*) connected with the sac: recurrent pulsation, dilatation of the sac

without pulsation with suppuration and sloughing; (*c*) connected with the limb: gangrene extending up as far as the sac.

(1) *Secondary hæmorrhage* is liable to occur at any period before the wound is soundly healed if strict asepsis is not maintained. The causes, symptoms, and treatment are discussed under *Hæmorrhage* (see p. 219).

(2) *Recurrent pulsation*, when slight, is a good sign, as it shows that the collateral circulation is becoming established, and consequently that the danger of gangrene is lessened, if not passed. If, however, instead of ceasing, as it usually does in a few days, it becomes more pronounced, the limb should be raised and carefully bandaged from the foot upwards, and pressure applied to the artery leading to the sac. If this does not suffice, and the pulsation returns as strongly as ever, and the aneurysm again begins to increase in size, it is clear that the ligature has failed, and it becomes a grave question what further treatment should be undertaken. Should it appear that a large branch is feeding the aneurysm, this should undoubtedly be secured; otherwise the choice will probably lie between—1, pressure upon the artery and aneurysm; 2, the use of Esmarch's bandage; 3, flexion in the case of a popliteal aneurysm; or, if these fail, 4, tying the vessel either just above the aneurysm or above the former ligature; 5, cutting down upon the sac, and securing both ends of the artery; 6, excision; or, 7, amputation. Much will turn on each individual case, and the discussion as to a choice of method is too long to be entered upon here. Generally it is best to excise the aneurysm.

(3) *Septic phlebitis* may occur from injury to the vein in passing the aneurysm needle. Should the vein be pricked, an accident which may be known by venous blood welling up by the side of the ligature, the artery should on no account be tied at this spot, as the ligature, should the wound become septic, would act as a seton in the vein, and death possibly ensue from phlebitis or pyæmia. The ligature, if already passed, should be withdrawn, pressure applied to the vein, and the artery tied higher up. Where this treatment has been adopted, we have never seen any ill results follow the injury.

(4) *Inflammation and suppuration of the sac* may be met with after pressure, as well as after ligature; and although it may occur after the Hunterian operation, is more frequent in cases where the ligature has been applied close to the sac, or where rapid pressure has been used. It appears to be due to—1, the spread of inflammation to the sac from the wound, which has become septic; 2, the formation in the sac of a soft coagulum; or 3, excessive manipulation before the operation. It is ushered in with redness, heat, pain, and swelling of the sac (which has not undergone the usual process of shrinking), and œdema of the surrounding parts. Later the skin gives way, and a mixture of pus and broken-down coagula

escapes. It may be accompanied by hæmorrhage; but more commonly the vessel has become sealed, and no bleeding occurs. The abscess should be opened as soon as pus has formed, a grooved needle being previously inserted if there is doubt on this point. Should hæmorrhage occur, the clots must be turned out, and the artery secured above and below, or the sac may be excised, or amputation performed.

(5) *Gangrene* is more common in the leg than in the arm; indeed, in the latter situation it is very rare. It may be due to—1, failure of establishment of the collateral circulation, when it usually supervenes within a few days; or, 2, venous obstruction, the result of plugging of the vein in consequence either of injury at the time of operation, or of pressure on the vein by a swollen and suppurating sac. When due to the latter conditions, it may be delayed for some weeks. When extensive and spreading rapidly, amputation at the seat of ligature must be performed at once. The surgeon, however, should not be in too much haste to amputate when the gangrene is dry, as it may involve only a toe or two, or part of the foot, and spread no further. When, therefore, it is limited in extent, and spreading slowly, a line of demarcation should be waited for before amputation is performed. When the sac is very large, and the gangrene appears to be due to pressure on the vein, the sac may at times be opened with advantage, the clots turned out, and any bleeding vessels secured, or the whole aneurysm may be excised.

B. **Anel's operation** was seldom done until recent years, except where the Hunterian method was inapplicable, as for aneurysm in the groin, aneurysm of the upper part of the common carotid, etc. The disadvantages said to attend it are—1, that the artery is likely to be diseased, and hence there is greater risk of secondary hæmorrhage; 2, that its anatomical relations are apt to be disturbed by the contiguity of the sac; 3, that the sac itself is liable to be injured during the operation, and to become inflamed and suppurate; and 4, that the clot which forms in the sac is of the soft non-laminated variety in consequence of there being no circulation in the sac. Since the introduction of antiseptic surgery this method has been revived at St. Batholomew's for the treatment of popliteal aneurysm, and the popliteal artery is there now frequently tied. It has been found to diminish the risk of gangrene, and holds out a greater certainty of cure. Gangrene is less likely to occur when only the popliteal is obstructed close to the aneurysm than when both the popliteal and femoral are blocked. Recurrent pulsation and failure after the ligature of the femoral are due to too free a supply of blood flowing into the artery below the ligature (Fig. 160); when the popliteal is tied this is prevented. Moreover the popliteal has been found quite as healthy as the femoral; it is easily tied at its upper part without

disturbing the sac; and there appear to be sufficient small vessels given off from the artery between the ligature and the aneurysm to ensure by their anastomosis with other small vessels given off above the ligature some circulation in the sac and the formation of an active clot. Lastly, inflammation and suppuration of the sac, if the wound runs an aseptic course, need not be feared.

2. **The distal ligature** should only be used where the Hunterian or Anel's method cannot be applied. *Brasdor's method*, which consists in securing the main trunk on the distal side of the aneurysm, may be employed in aneurysm of the carotid at the root of the neck. It copies that method of spontaneous cure in which a clot blocks the artery beyond the aneurysm. After the ligature the clot that forms in the artery may extend to the aneurysm, which thus becomes filled by a coagulum; or the blood pressure in the sac may become so diminished that laminated fibrin is deposited. Unfortunately, however, in practice the blood pressure in the aneurysm appears in some cases to be increased rather than diminished. *Wardrop's method* consists in securing two or more of the main branches of the artery on the distal side of the aneurysm. It aims at cutting off part of the blood stream through the aneurysm, and so, by reducing the blood pressure, promoting the deposition of laminated coagulum. It has been applied to the subclavian and carotid arteries for aneurysm of the innominate; but the success attending it has not been great. The chief risks are further enlargement and subsequent bursting of the sac, or inflammation and suppuration of the sac.

3. **The double ligature.**—Ligature above and below the sac, either, 1, by the old method of first laying the sac open and then securing the bleeding ends of the artery, or, 2, by the method of Antyllus, of first securing the artery and then laying the sac open, is only employed in exceptional cases. Thus the *old method* is sometimes resorted to in traumatic aneurysm of the axillary artery in preference to tying the subclavian, and also in gluteal aneurysm where tying the common or internal iliac is attended with much risk. The great danger is the patient dying under the operation of hæmorrhage. During the operation, therefore, in the case of the axillary artery, pressure should be made on the subclavian, or, to ensure its better control, through an incision above the clavicle; or a temporary loop may be put round the subclavian, which is then drawn up against his finger by an assistant. In the case of the gluteal, the internal iliac should be first tied by the transperitoneal method. The true *method of Antyllus* may, in rare instances, be required, as in some forms of aneurysm at the bend of the elbow.

Excision of the whole aneurysm.—Of late years many successful cases of the complete excision of spontaneous aneurysm have been recorded. One of us (Walsham) thus recently removed a large carotid aneurysm at St. Bartholomew's. The sac should be

exposed, the artery sought on the proximal side, tied in two places and divided. The sac should be next carefully dissected out, the artery on the distal side tied, and the whole aneurysm removed. The advantages of total extirpation are—1, the aneurysm being got rid of, the cure is radical, whereas after other methods recurrence may take place even after months or years; 2, the danger of soft clot being washed out of the sac into the circulation is removed; 3, all vessels that are likely to give rise to secondary hæmorrhage can be ligatured; 4, the cicatricial contraction of the sac and consequent risk of the involvement of nerve trunks or the impairment of mobility in joints is avoided. The disadvantages of the operation are—1, the difficulty of its execution; 2, the danger of wounding important parts to which the sac has formed adhesions, as the attendant vein or nerve trunks; and 3, the risk of rupture of the sac and severe hæmorrhage during the long and tedious dissection that may be required. The argument that the artery near the sac is unhealthy has no weight, since it has been shown of late that atheroma is not oftener found there than at a distance, and markedly atheromatous arteries can be occluded by sterile ligatures without fear of secondary hæmorrhage. If excision is practised the operation in some cases may be done at two sittings. The arteries arising from the sac may be first tied, also the main artery on the distal side; then, after a week or so, the wound is reopened and the shrunken sac excised after tying the proximal vessel

The introduction of silver or gold wire has been attended with some success of late. A small trocar and cannula is introduced into the sac, the trocar withdrawn, and many yards of the wire are introduced into the sac through the cannula. The wire causes coagulation of the blood, and thus leads to consolidation. The wire, *e.g.*, hard-drawn No. 30 gold wire, must readily form coils after passing through the needle.

Irritation of the interior of the sac by needles (*Macewen's method*).—This method aims at scratching the interior of the sac of the aneurysm so as to induce slight inflammation and the formation of laminated fibrin. The skin having been made aseptic, long, fine, polished steel needles are passed into the sac, and the wall systematically scratched all round the aneurysm; no hæmorrhage follows. It is applicable to aneurysms where pressure or proximal ligature cannot be employed. Consolidation occurs very slowly. No harm has followed, and in some cases much good.

Electrolysis.—The use of this method requires full technical knowledge, otherwise it should not be attempted.

Manipulation, injections of perchloride of iron, tannin, and the like, which have all for their object the coagulation of the blood in the sac, are highly dangerous procedures, and have not hitherto been attended with success. The sac may suppurate or clot become detached and cause pulmonary or septic embolism.

Arterio-venous aneurysm, see p. 276. *Cirsoid aneurysm* or *aneurysm by anastomosis*, see p. 276.

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SPECIAL ANEURYSMS.

Internal aneurysms, falling as they do under the care of the physician rather than of the surgeon, will be referred to only in as far as an aneurysm of the arch of the aorta, of the innominate, of the first portion of the subclavian, and of the portion of the left common carotid within the chest may present as a pulsating tumour at the root of the neck, and as such may call for surgical treatment.

Aneurysm at the root of the neck.—The differential diagnosis of aneurysm in this situation is always difficult, at times impossible. Indeed the aneurysm may involve more than one artery, perhaps all three of the main branches of the aortic arch, and even the arch itself as well. The sign common to all forms, whatever the artery implicated, is a pulsating tumour at the root of the neck, in which a loud bruit can generally be heard. When the aneurysm involves the *aorta*, it generally presents just above the suprasternal notch, and there are symptoms within the chest of the aorta being affected. When the *innominate* is implicated, the aneurysm projects between the two heads of origin of the sterno-mastoid muscle; and the pulse in the temporal and radial arteries is smaller on the right than on the left side, is delayed, and is aneurysmal in character (see p. 386). When the aneurysm involves the *common carotid*, it presents beneath the inner head of the sterno-mastoid, and tends to bulge upwards in the neck by the side of the trachea; the bruit is transmitted up the carotid, and the pulse in the temporal is smaller on the affected than on the sound side, and is aneurysmal; but the pulse in the radial is the same on both sides. When the *subclavian* is involved, the tumour is external to the sterno-mastoid; it extends in the direction of the subclavian artery, the bruit is transmitted towards the axilla, and the pulse at the wrist is diminished in volume and is delayed. There are many other signs of aneurysm at the root of the neck:—pressure on the subclavian, jugular or innominate vein, as shown by fulness in the obstructed vein; on the right or left thoracic duct, attended by wasting, pleural exudation of chyle, etc.; on the nerves of the brachial plexus, the sympathetic, recurrent laryngeal, especially the left, or phrenic causing paralysis; on the œsophagus causing dysphagia; and on the trachea producing dyspnœa (see further in a work on Medicine).

Treatment.—The treatment is primarily medical, and only when this proves unavailing should other means be considered. When a sacculated aneurysm is bulging into the root of the neck or forwards between the rib cartilages, the inside of the sac may be scratched with Macewen's needles, or wire inserted; or, supposing

the carotid and subclavian arteries still to be patent, these may be ligatured on the distal side; but if pulsation is already small or not to be felt in them, there is no object in attempting the distal ligature.

Subclavian aneurysm.—An aneurysm may be situated upon the artery in its *first part* or include the bifurcation of the *innominate*, so that it is impossible to apply a ligature to the artery on the proximal side of the aneurysm. For this aneurysm a ligature has been applied to the innominate, and at the same time to the common carotid, with success in several cases. The carotid must be simultaneously tied to prevent the recurrent flow from disturbing the closure of the artery on the distal side of the ligature.

An aneurysm situated on the *second part* of the subclavian, even when involving the outer end of the first part, has been recently cured by ligature. A proximal ligature may be applied in the first instance, and if pulsation recurs the distal end of the artery and the arteries leading off from the sac, the vertebral, internal mammary, inferior thyroid, supra-scapular and transversalis colli, springing together from the thyroid axis, or separately, may be ligatured at a second operation, and if practicable the sac excised. Or if the proximal end cannot be reached on account of the size of the aneurysm, an attempt may be made by ligaturing the distal artery and the other vessels springing from the sac to reduce the size of the aneurysm, and so facilitate reaching the proximal artery previously overlapped by the tumour.

An aneurysm of the *third part* of the subclavain, if moderately small, should be excised, if necessary dividing or removing a portion of the clavicle as a preliminary. If already extensive, the artery on the proximal side may first be ligatured, then the distal end and the communicating vessels; next the sac is opened, clot turned out, and the wall excised in part so as to free the patient if possible from pressure on the nerves.

Other measures, such as inserting gold wire, distal ligature alone, or the terrible expedient of amputating at the shoulder-joint, fail in two directions, either the aneurysm is not arrested in its development, or pressure on the brachial plexus continues to cause pain.

Carotid aneurysm.—Aneurysm of the carotid at the root of the neck is generally an extension of an innominate one. Aneurysm of the common trunk higher in the neck presents the ordinary signs of aneurysm, and in this situation has to be diagnosed from—1, simple dilatation of the artery at its bifurcation; 2, enlarged glands; 3, abscess or tumour over the artery; 4, pulsating goitre. In simple dilatation there is no bruit; in enlarged glands and tumours there is also no bruit, and the pulsation is not expansile, and ceases when they are lifted up from the vessel; in abscess, in addition to the absence of the above signs, there is the history or presence of inflammation; in pulsating goitre the tumour moves up

and down with the larynx on deglutition. The usual *treatment* consists in ligature of the artery below the aneurysm. In a case recently, under the care of one of us (Walsham), a large carotid aneurysm was dissected out, and the patient made a good recovery. Whenever practicable this is the best method of treatment.

Aneurysm of the external carotid artery or one of its branches, whether a cirsoid aneurysm or traumatic in origin, should always be treated by excision.

Aneurysm of the internal carotid.—An *extracranial aneurysm* is very rare, *e.g.*, from septic inflammation under the skull. The only frequent one is intracranial.

Intracranial or cavernous aneurysm is also called *orbital* or *intra-orbital*, but this latter term is not really applicable, for in only one instance has a circumscribed orbital aneurysm been verified by an autopsy. In fatal cases the following conditions have been found:—1. Thrombosis of the cavernous sinus. 2. Aneurysmal varix between the internal carotid and the cavernous sinus. 3. Dilation of the carotid artery. 4. Aneurysm on the ophthalmic artery *within* the skull. As so many cases are cured, there is no means of verifying the diagnosis; but, broadly speaking, it may be said that in such cases there is a slight leakage into the cavernous sinus from the internal carotid artery, the ophthalmic or the anterior communicating.

The *general symptoms* are:—Pulsation over the whole or part of the orbit; protrusion of the eyeball, with loss or impairment of sight; more or less pain; signs of pressure on the third nerve; and a loud bruit which can also be often heard by the patient himself. *Treatment.*—The symptoms have been known to subside spontaneously after rest in bed and iodides. Where they have not done so ligature of the carotid has been attended with the best results; but the opposite carotid as well, in some cases consequent upon too free a collateral circulation having become established through the circle of Willis, has had to be tied some weeks subsequently. Where the pulsation has followed a punctured wound of the orbit it has been advised to extirpate the globe and secure the bleeding vessel in the orbit. But this sacrifices the eye and is dangerous. Ligature of the common carotid is the best treatment, especially when compression checks the pulsation and the bruit.

Axillary aneurysm is not uncommon as the result of sprains, or of attempts to reduce long-standing dislocations of the shoulder. The *diagnosis*, as a rule, presents no difficulty except the aneurysm has become diffused, when it may be mistaken for abscess. *Treatment.*—1. When the aneurysm is spontaneous, small, and well circumscribed, excision or ligature of the third part of the subclavian should be practised. 2. When more or less diffused, as when the result of an injury to the artery in the reduction of a dislocation, the third part of the subclavian should first be tied, then the aneurysm should be cut down upon, the clots turned out,

the vessel secured on the distal side and the cavity stuffed with antiseptic gauze. This method is less dangerous than that practised by Syme, who made a free incision over the aneurysm, rapidly turned out the clots, and seized with forceps the bleeding point in the artery.

Brachial aneurysms at the bend of the elbow were formerly common when venesection was in vogue, and were then generally arterio-venous in character (p. 276). They should be excised.

Abdominal aneurysm is generally treated medically. The only successful surgical measure has been the insertion of gold or silver wire after exposing the sac by an incision through the abdominal cavity, or Macewen's needles may be used.

Gluteal aneurysm is the term applied to aneurysm of the gluteal artery itself, the sciatic, or the pudic where it winds over the spine of the ischium. Aneurysms in this situation may be the result of a wound or other injury, or may occur spontaneously. They are frequently attended with pain, from pressure on the sciatic nerve, and there may be some interference with the movements of the hip-joint. The pulsation and bruit will generally serve to distinguish them, but there may be no pulsation, as where the aneurysm has burst, or blood has been effused into the tissues as the result of a wound of the artery; a tumour of bone, moreover, may also pulsate. Under such circumstances, exploration with a grooved needle will be necessary. *Treatment.*—The internal iliac artery should be tied by the transperitoneal method. This is a much safer procedure than cutting down on the aneurysm and securing the ends of the bleeding vessel. After the iliac has been secured the sac can be exposed without much hæmorrhage, the distal vessel tied, and the aneurysm dissected out or plugged.

Inguinal and iliac aneurysms.—*Inguinal aneurysms* are those which involve the termination of the external iliac. They may extend either upwards along the course of the external iliac into the abdomen, or downwards in the course of the femoral into the thigh. *Iliac aneurysms* are those involving the upper part of the external iliac or common iliac, and are situated in the iliac fossa. Inguinal and iliac aneurysms may have to be diagnosed from enlarged inguinal glands over the artery, tumours, especially pulsating tumours of the pelvic bones, and abscesses. From abscess and tumour they may be distinguished by the signs already several times alluded to. Their diagnosis from pulsating tumours of bone is often very difficult, and the external iliac has before now been tied by the most able surgeons under the impression that such a tumour was an aneurysm. The diagnostic points have already been given under *Pulsatile Tumours of Bone* and *Diagnosis of Aneurysm* (pp. 362, 388).

Treatment.—1. When the aneurysm is of moderate dimensions, and involves only a small portion of the external iliac, this vessel should be tied by the transperitoneal method, or, if preferred, an

attempt may first be made to compress it. 2. Where there is apparently not room to apply a ligature to the external iliac, the common iliac may be tied by the transperitoneal method or the aneurysm may be excised, avoiding, if possible, injury to the iliac vein.

Femoral aneurysms are situated in Scarpa's triangle or Hunter's canal. They are easy of diagnosis except where the skin is inflamed and brawny, when they may be mistaken for an abscess. When situated in Hunter's canal, the femoral should be compressed or tied in Scarpa's triangle. When situated in Scarpa's triangle, the external iliac or common femoral may be treated in the same way. In either situation the aneurysm, if circumscribed, may be dissected out.

Popliteal aneurysm is the commonest surgical aneurysm. The frequency of aneurysm in this situation is attributed to—1, the bifurcation of the popliteal artery into the anterior and posterior tibial, whereby the circulation through it may be slightly obstructed, or an embolus be readily impacted ; 2, the artery being unsupported by muscles and in contact with the bone ; 3, the strain on the artery in the movements of the knee-joint ; 4, the compression that may be exerted on the end of the artery by the strong fibrous arch of origin of the soleus muscle. A popliteal aneurysm is often bilateral, and is nearly always seen in men. Whilst syphilis is often the cause, yet this aneurysm may appear in young men without any such condition being present. A popliteal aneurysm is not usually difficult to diagnose, but should it become diffused, suppurate, or break into the knee-joint, it may be mistaken for a malignant tumour of the bones, an abscess, or an affection of the joint. The history of the case, the consideration of the diagnostic signs of aneurysm already given, and the introduction of an exploring needle into the knee when blood has been effused into the joint, will usually clear up any doubt as to the nature of the affection.

Treatment.—Little need be added here to what has already been said on the general treatment of aneurysm, as such especially applies to aneurysm in this situation. Flexion, digital and instrumental compression, and Esmarch's bandage are no longer considered advisable on account of their tendency to dilate the anastomotic circulation, and so neutralise the effect of ligation, should this become necessary, by carrying too much blood round to the sac. Most surgeons, therefore, at once tie the popliteal in the upper part of its course, or the femoral artery in Hunter's canal or in Scarpa's triangle. The operation of tying should be done at once under the following circumstances : — 1. When the aneurysm is rapidly increasing in size, leaking, or threatening to burst. 2. When the aneurysm is inflamed but has not suppurated. 3. Under some circumstances when it has burst into the knee-joint. 4. When the limb is œdematous, showing that the vein is being seriously compressed. 5. When

the patient is of an irritable disposition, addicted to alcohol, and impatient of control. Extirpation of the sac, or at least ligature above and below and the turning out of the clot, may be undertaken —1. When the aneurysm has burst or become diffused; and 2. When other methods have failed to cure it. Amputation, on the other hand, is, as a rule, called for—1. If gangrene has set in. 2. If suppuration attended with profuse hæmorrhage has occurred; and 3. If the knee-joint is disorganised.

12\1\03.

LIGATURE OF ARTERIES.

The *ligature of arteries* requires a knowledge of their relational anatomy and of the position and appearance of the various structures which serve as guides to them. Such a knowledge can only be gained in the dissecting-room, and by the frequent practice of operations on the dead body. Here only the chief rules that should guide us in applying a ligature, and a short account of the methods of tying the more important arteries, can be given. It need hardly be said that the *strictest* precautions should be taken to ensure an *aseptic operation*, since upon this, perhaps, more than upon anything else mentioned in the following rules, will success depend.

General rules for ligature.—1. The incision should generally be made parallel to the course of the artery and the skin divided evenly to promote union by first intention. 2. Each successive cut through the underlying tissues should be made the same length as that through the skin, and bruising of the parts avoided as much as possible. 3. The sheaths of muscles and tendons should not, if possible, be opened. 4. The sheath of the vessel having been exposed and the artery felt pulsating with the index finger, the sheath should be pinched up with forceps and opened by cutting with the blade of the knife on the flat. 5. The sheath being opened, it must be separated from the artery in the whole of its circumference, either by careful dissection with the knife turned with its edge from the artery, or by a blunt-ended, unthreaded aneurysm needle, or the director insinuated by a gentle to and fro movement between the sheath and the artery. If this part of the operation is not done very delicately, too much of the sheath in the long axis of the artery will be separated, and there will be danger of secondary hæmorrhage from cutting off of the blood supply which the vessel receives from the sheath, or the accompanying vein may be punctured. 6. Having separated the sheath, one side of it should be seized with the forceps and the needle passed, unthreaded, between it and the artery, and the point, by a gentle to and fro movement, carried round the vessel without injuring or including any of the contiguous structures. It should, save in exceptional cases which will be mentioned, be passed from the side on which the main vein lies. It is better also to separate venæ comites, although if small

these may without detriment be included in the ligature. 7. When the point of the needle projects on the opposite side, it should be cleared from any loose cellular tissue of the sheath it may have carried before it by scratching with anatomy forceps or the finger-nail, or cutting on the needle with the edge of the scalpel directed from the artery. 8. The artery should be gently pressed between the curve of the needle and the finger to ascertain that no other structure is included, and that pressure controls the pulsation in the aneurysm. 9. The needle should now be threaded with the ligature, which is carried round the artery as the needle is withdrawn; the ligature should then be tied in a knot and its ends cut off short. 10. Should much of the sheath have been unavoidably separated from the artery, two ligatures had better be passed, and the artery divided between them. We question if this will not always be found the safer method for moderate-sized vessels in easily accessible situations. For large arteries like the innominate, carotid, subclavian or iliacs division is dangerous, and a ligature in continuity should be used. 11. Some form of aseptic ligature should be employed, as silk, chromicised catgut, ox-aorta, or kangaroo-tail tendon, but the best material can hardly be said to have been determined, although generally kangaroo-tail tendon is found to answer admirably. 12. If the vein is wounded, a ligature or pressure may be applied and the artery tied a little higher up. 13. The wound should be accurately united, drained if deep, and dressed antiseptically. 14. For the form of ligature knot, see p. 213.

THE LIGATURE OF SPECIAL ARTERIES.

The innominate artery.—Its ligature has been one of the most difficult and dangerous of operations, owing to the great liability to secondary hæmorrhage, but several cases have been recently successful. It is indicated for aneurysm or punctured wound of the right subclavian and carotid arteries so close to or actually involving the bifurcation of the innominate that it is impossible to place a ligature on these vessels on the proximal side of the aneurysm or wound. One of three methods may be used to expose the artery.

(1) The head being extended as much as possible by placing a pillow behind the shoulders, a median incision is made from the cricoid cartilage downwards over the manubrium, the median raphé of the sterno-hyoids divided in the same line, and then the sterno-hyoid and sterno-thyroid muscles retracted on each side. The carotid artery is sought for just in front of the right side of the trachea, its sheath opened as far down as possible on the inner side, and a ligature placed round the carotid and tied tightly. By following down the carotid so laid bare and drawing it up a little by the ligature, the innominate is exposed below its bifurcation, its sheath opened on its anterior aspect, a ligature passed round it and tied. This median

incision is serviceable in that no muscle or bone is divided which may subsequently ooze and fill the wound with decomposable blood-clot, nor is any important vessel wounded, only inferior thyroid veins, also the arteria thyroidea ima if one is present, but these can be easily controlled. The early exposure of the carotid forms a safe guide to the innominate, whilst the internal jugular vein and the vagus, sympathetic and phrenic nerves lie well outside. The innominate is exposed having the internal jugular and subclavian veins united in the right innominate to the outer side, and the left innominate vein crossing below the point for applying the ligature. The innominate artery is there uncovered by pleura, the right fold of which lies to the right, whilst the operation wound generally keeps as far as possible from the aneurysm, or from any plug or finger temporarily controlling hæmorrhage. But it is impossible to get the ligature round if the bifurcation of the innominate is low.

(2) After making the foregoing skin incision the manubrium is cut through down the middle line to the gladiolus, especial care being taken not to injure the left innominate vein behind. Then the right half of the manubrium is raised and cut away by dividing the sterno-clavicular articulation and the first rib cartilage. This will serve to expose the innominate artery, with the left innominate vein crossing it to join the right just to its outer side, these veins and the right fold of the pleura expanding with expiration and being sucked in with inspiration, whilst the phrenic, the vagus and sympathetic in front and around the first part of the subclavian, also the right internal mammary artery, should lie well to the outer side. Thus there is room to apply the "stay-knot" of Ballance and Edmunds (Fig. 85).

(3) By an angular incision down the neck to the sternum and then along the clavicle, the skin is divided, and then the attachments of the sterno-hyoid, sterno-thyroid, and sterno-mastoid muscles to a greater or less extent. Such an incision has been proved to have many objections; by the retraction of these divided muscles a cavity has formed into which blood oozed, decomposed, and led to secondary hæmorrhage. Further, the incision comes down upon the aneurysm which may block the way to finding the innominate behind the sterno-clavicular joint, until the carotid is sought for and followed down as in the median incision. Also in the way to the artery are the internal jugular and subclavian veins joining to form the right innominate to say nothing of smaller veins and the right thoracic duct; also the phrenic, vagus and sympathetic nerves are disturbed in front and around the first part of the subclavian, and are difficult to make out if the artery is aneurysmal. Doubtless their irritation has had much to do with the shock some of the patients received.

It is necessary in all cases to tie the common carotid, otherwise such is the regurgitant flow through that artery over the distal side of the ligature that secondary hæmorrhage is most likely. The branches

of the first part of the right subclavian, the vertebral, internal mammary, and inferior thyroid, may be so dilated as to prevent shrinkage of the sac. If so, either at the same, or perhaps more safely at a subsequent operation they must be ligatured. All bleeding is arrested, divided muscles sutured, and the wound closed without drainage. Blood and exudation have collected in a cavity to which pressure could not be applied, and have become infected through the drainage tube, followed by fatal secondary hæmorrhage. The collateral circulation is carried on through the upper intercostals into subclavian and axillary branches; from the iliac through the

FIG. 161.—Incisions in certain operations on the neck and face. A. Ligature of temporal artery; B. Exposure of infra-orbital nerve; C. Kocher's operation for removal of tongue; D. Ligature of common carotid artery; E. Ligature of subclavian artery (3rd part).

deep epigastric into the internal mammary; from the carotid and subclavian on the left side through the inferior thyroid and vertebral into the corresponding arteries of the right side; and through the circle of Willis.

The common carotid artery may be *compressed* for a short while by grasping the neck with the fingers whilst pressing back the artery against the spine with the thumbs, one over the other; or the artery may be pinched between the fingers in front and the thumb behind the sterno-mastoid.

Ligation may be required for—1. Wound of the common or internal carotid artery, *e.g.*, a punctured wound near the angle of the jaw or tonsil; 2, ulceration into the common carotid artery, *e.g.*, by septic inflammation, or into the internal carotid artery outside or

in its course through the carotid canal; 3, aneurysm of the common carotid in its upper part, at its bifurcation; 4, orbital, intracranial and cirsoid aneurysm; and 5, aneurysm at the root of the neck (distal ligature). The artery may be tied either above or below the omo-hyoid. When practicable it should be tied above, as it is here more superficial, and the risk of suppuration extending beneath the deep fascia into the chest is avoided. *The high operation, or ligature above the omo-hyoid.*—Having turned the head to the opposite side, make an incision three inches in length with its centre opposite the cricoid cartilage, along the anterior edge of the sterno-mastoid muscle, *i.e.*, in a line drawn from the sterno-clavicular articulation to a point midway between the angle of the jaw and the mastoid process (Fig. 161, D). Divide the skin, superficial fascia, platysma and deep fascia. Draw the anterior edge of the sterno-mastoid gently outwards, and the artery will be felt pulsating in the angle formed by the omo-hyoid with the sterno-mastoid. Open the sheath on its inner side, and pass the aneurysm needle from without inwards to avoid injuring the vein which slightly overlaps the artery on its outer side, and keep its point close to the vessel lest the pneumogastric nerve behind be included in the ligature. The small descendens cervicis nerve runs superficial to the sheath, and if seen, should be avoided. The superior thyroid, lingual and facial veins cross the artery to open into the internal jugular vein. Should they impede the operation, divide them between clamp forceps. *The low operation, or ligature below the omo-hyoid.*—Make an incision in the same line as for the high operation, but lower in the neck (Fig. 163, i). Draw the sterno-mastoid outwards and the sterno-hyoid and thyroid inwards and the artery will be felt beating in the angle formed by the omo-hyoid with the sterno-thyroid. Pass the needle as before from without inwards, taking especial care not to injure the internal jugular vein which on the left side slightly overlaps the artery. The head should be kept fixed after ligature by sand-bags or some form of splint.

The *chief dangers* after ligature are—1. Secondary hæmorrhage from a septic ligature. 2. Paralysis. (*a*) Immediate hemiparesis of the opposite side, from temporary anæmia in the area of the middle cerebral artery, or definite hemiplegia if thrombosis takes place. (*b*) Hemiplegia on the ligatured side coming on after a few days from septic cerebral softening consequent upon the detachment of a septic clot from the proximal side of the ligature, which has then been carried up the opposite carotid. 3. Septic pneumonia from suppuration in the wound or in the aneurysmal sac. 4. Irritation of the pneumogastric may cause a momentary arrest of the heart, or respiration, and division the paralysis of the vocal cord of that side, but is not a cause of pneumonia unless the wound is also septic. 5. A ligature of both carotids simultaneously has caused fatal coma—at least two weeks should intervene; and a similar result

might follow the ligature of one artery, if the opposite artery be already occluded.

The collateral circulation (1) from the subclavian artery of that side through the inferior thyroid and vertebral or through the cervical branches into the princeps cervicis of the occipital; (2) from the opposite internal carotid through the circle of Willis into the internal carotid of the ligatured side, and then by back flow to the bifurcation and into the external carotid; (3) from the opposite external carotid through its branches into the corresponding branches on the ligatured side (Fig. 162).

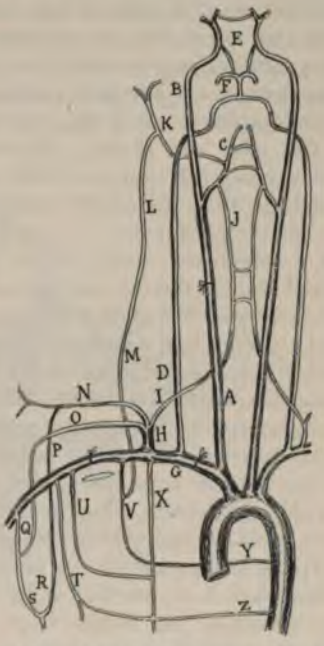


FIG. 162.—Diagram to show the collateral circulation after ligature of common carotid, subclavian and axillary arteries. A. Common carotid; B. Internal carotid; C. External carotid; D. Vertebral; E. Circle of Willis; F. Basilar; G. Subclavian; H. Thyroid axis; I. Inferior thyroid; J. Superior thyroid; K. Occipital; L. Princeps cervicis; M. Deep cervical; N. Transversalis colli; O. Suprascapular; P. Posterior scapular; Q. Dorsalis scapulæ; R. Infra-scapular; S. Subscapular; T. Long thoracic; U. Short thoracic; V. Superior intercostal; X. Internal mammary; Y and Z. Aortic intercostals.

The internal carotid artery hardly ever requires to be ligatured. A ligature of the common carotid, with or without ligature of the external carotid, is generally to be preferred, except in excising a carotid aneurysm developing at the bifurcation. A punctured wound is practically always of the external carotid artery or one of its branches; a wound of the internal carotid being mostly fatal at once. The ligature of the internal carotid in excising a deep-seated malignant tumour is rarely successful, not only from the dangers mentioned under ligature of the common carotid, but also from the difficulty or impossibility of securing the distal end. Hæmorrhage, from septic sloughing and ulceration, into the internal carotid is so immediately dangerous to life and so impossible to make the field of an operation, that ligature of the common carotid at some distance from the septic inflammation offers the only chance. Hæmorrhage from the ear following otitis is exceptionally uncontrollable, presumably due to ulceration into the carotico-tympanic twig given off near the

bend of the artery in the canal. Such cases have been successfully arrested by ligature of the common carotid. If, however, the wall of the artery itself is involved, nothing probably will avail. For intracranial aneurysm ligature of the common carotid is so much the easier.

The internal carotid lies deeper, at first a little outside the external carotid, having the internal jugular vein external, and behind and outside the vagus and sympathetic nerves, the superior laryngeal nerve passing along between the artery and the vein.

The external carotid artery.—A ligature is required for (1) a punctured wound in the submaxillary region; (2) hæmorrhage from the nose and throat; (3) for a cirsoid aneurysm; (4) in the course of removing tumours from the submaxillary region; (5) for hæmorrhage from the middle meningeal which cannot be controlled inside the temporal bone.

(1) A punctured wound in the submaxillary region from which arterial blood is flowing will almost certainly involve the external carotid artery or one of its branches, and not the internal or common carotid. Hence it is a mistake in such a case to ligature the common carotid. Not only is hæmorrhage likely to continue, owing to the free anastomosis between the external carotids of the two sides, but also a regurgitant hæmorrhage from the circle of Willis will take place down the internal carotid and so into the external, whilst at the same time the patient may suffer from the cutting off the blood supply to one side of the brain, when he has already been rendered generally anæmic by the primary hæmorrhage, The rule should be to enlarge and explore the wound for the bleeding point, and to apply ligatures on either side of it, whether it be the external carotid itself or one of its branches, the hæmorrhage being controlled meanwhile by temporary pressure on the common carotid, or by passing a ligature round the artery and drawing it forwards against the assistant's finger, removing the loop as soon as the bleeding point has been secured. (2) For hæmorrhage from the nose or throat, except in the case of the tongue, there is so free a communication between the two sides that the ligation must generally be done at the same time on both sides, if it is really required. (3) The foregoing remarks apply to the case of cirsoid aneurysm. Therefore, as regards both (2) and (3), surgeons generally rely on tying the individual branches involved. (4) In removing tumours from the submaxillary region, the external carotid if involved is excised or only its branches are tied.

The external carotid artery may be ligatured anywhere in its course between the hinder and upper angle of the thyroid cartilage and a point midway between the angle of the jaw and the mastoid process. An incision is made in this line, veins joining to form the external jugular are clamped, the anterior border of the sterno-mastoid retracted, the stylo-hyoid and the posterior belly of the digastric are retracted, whilst facial and lingual veins going to the

internal jugular are divided between clamps, and the submaxillary gland hooked upwards. The artery should generally be tied in two places and divided between the ligatures to prevent the regurgitant hæmorrhage, and any branch arising near should also be secured.

Branches of the external carotid—The superior thyroid.—This artery requires to be tied (1) when wounded, as in "cut throat"; (2) to check enlargement of a vascular goitre, or in the course of removing one; (3) in excision of the larynx. An incision is made along the anterior border of the sterno-mastoid, which is retracted, and the artery sought for near its origin, just behind the great cornu of the hyoid bone, or where it enters the upper and back

Fig. 163.—Incisions in certain operations on the neck. *a*. Subhyoid pharyngotomy. *b*. Thyrotomy. *c*. Laryngotomy. *d*. Tracheotomy above, and *e* below, the isthmus of thyroid. *f*. Ligature of subclavian (3rd part). *g*. Ligature of lingual. *h*. Ligature of temporal; exposure of auriculo-temporal nerve. *i*. Ligature of common carotid.

part of the lateral thyroid lobe. The superior laryngeal nerve runs above and to its inner side.

The lingual artery may be compressed when bleeding into the mouth by passing the finger down to the epiglottis, then hooking it outwards under the angle of the jaw. It may require ligature for hæmorrhage in cancer of the tongue, and as a preliminary to excision of the tongue. Make an incision along the greater cornu of the hyoid bone (Fig. 163, g); divide the skin, superficial fascia and platysma; hook up the submaxillary gland, and a few touches of the director will expose the triangle bounded below by the anterior and posterior belly of the digastricus and above by the hypoglossal nerve. Scratch cautiously through the muscular fibres of the hyoglossus, which forms the floor of this triangle, taking care not to

injure the lingual vein which is superficial to the muscle; the lingual artery will be seen or felt lying upon the middle constrictor of the pharynx. The vessel, however, is sometimes abnormal, and consequently may not be found in the usual situation. It is then sought by extending the incision backwards towards its origin.

The lingual artery may also be tied just as it comes off from the external carotid, as it lies on the middle constrictor between the greater cornu of the hyoid bone and the posterior belly of the digastricus. The operation is more difficult, but the supply of blood to the back of the tongue through the dorsalis linguæ branches is also cut off. The vessel is exposed through an incision along the anterior edge of the sterno-mastoid, similar to that for ligature of the external carotid.

The facial artery is readily compressed or tied at the anterior edge of the masseter, where it can be felt beating. It lies anterior to its vein. It has frequently to be tied in its course through the neck in the removal of glands from that region. When the submaxillary triangle is incised and the gland hooked up, the tortuous artery is stretched out, extending from the posterior belly of the digastric and stylo-hyoid muscles across to the gland behind the posterior border of the mylo-hyoid and above the hypoglossal nerve.

The temporal artery may require ligature for cirsoid aneurysm or a wound of the vessel. It can be readily secured at the spot where it is felt beating as it crosses the zygoma just in front of the external auditory meatus (Fig. 161, A, 163, h).

The occipital artery may require to be tied (1) for a wound; (2) in removing a tumour, especially a cirsoid aneurysm. It is to be found as it becomes superficial midway between the occipital protuberance and the mastoid process. Before this it runs so deeply that the external carotid should be tied before and beyond its origin.

The middle meningeal is injured in the foramen spinosum or in the temporal groove by fracture, also in the course of removing the Gasserian ganglion. If it cannot be controlled locally or by plugging the canal, the external carotid should be ligatured below in the neck and the temporal above.

The subclavian artery may be *compressed* against the first rib by the two thumbs, one over the other, in the subclavian fossa immediately above the clavicle, or a key may be wrapped round with lint and used for the purpose. The safest plan is to make an incision and pass a loop of a ligature round the artery.

The artery may be *tied* in the *third part of its course* for—1, axillary aneurysm; 2, aneurysm at the root of the neck (distal ligature); 3, ruptured axillary artery; 4, secondary hæmorrhage after amputation at the shoulder-joint; and 5, as a preliminary to the latter operation. The head having been drawn well back, the face turned to the opposite side and the shoulder depressed, draw down the skin over the clavicle, make an incision along the middle third of that bone

through the integuments and platysma, so as to avoid injuring the external jugular vein, and let the tissue slip up again (Fig. 161, E; 163, f). Next divide the deep fascia on a director, and the posterior edge of the sterno-mastoid will be exposed. Hold aside, or divide if necessary between clamp forceps, the external jugular or any other vein that may be in the way, but do not injure the supra-scapular artery, as this is one of the chief vessels by which the collateral circulation will subsequently be carried on. Search with the finger and director for the scalene tubercle in the triangle bounded by the omo-hyoid above, the clavicle below, and the scalenus anticus on the inner side: the artery will be felt pulsating behind the tubercle. It has the vein in front of it, but on a lower plane, and the brachial plexus above it. The lowest cord of the brachial plexus may indeed lie in front or behind the artery. Pass the aneurysm needle from above downwards, and before tying the artery gently raise it, see that it pulsates, that it can be flattened by finger pressure, and that this stops the pulse at the wrist. By this means the artery is distinguished from the firm cylindrical nerve cord. The artery is tied in the *second* part by making the incision further inwards, dividing the outer clavicular attachment of the sterno-mastoid, drawing the phrenic nerve inwards, dividing some of the fibres of the scalenus anticus, and separating the artery with great care from the dome of the pleura, which is grooved by the artery and is blown up into the wound during expiration. Ligature of the *first* part of the subclavian has been done both on the right and left sides recently with success, and presents similar difficulties to that of the innominate. On the right side the artery may be reached without removing bone, on the left side the inner part of the clavicle requires to be removed. (Further see *Ligature of the innominate artery*, p. 405).

The *principal accidents* that may occur during ligature of the subclavian in the third part of its course are—1, injury of the subclavian vein, and profuse venous hæmorrhage; 2, wound of the sac of the aneurysm in the second part; 3, inclusion of a cord of the brachial plexus; 4, puncture of the pleura; and 5, injury of the phrenic nerve. The *chief dangers after ligature* are pleurisy, secondary hæmorrhage, and suppuration of the sac. The *collateral circulation* (Fig. 162) after ligature of the third portion is carried on by—1, the supra-scapular and posterior scapular arteries anastomosing with the infra-scapular, subscapular, and dorsalis scapulæ arteries; 2, the internal mammary, superior intercostal and aortic intercostal arteries anastomosing with the long and short thoracic arteries.

Branches of the subclavian.—*The inferior thyroid artery* may be ligatured with the object of reducing the size of a vascular bronchocele, which it enters at the lower and deeper part, where great care must be taken to avoid the recurrent laryngeal nerve, which, running beside the trachea, may pass either behind or in

front of the artery or between its branches. Deeper down the artery may be tied, by the same incision as for the vertebral, where it crosses the line of that artery between the carotid tubercle and the sterno-clavicular articulation; the sympathetic nerve often crosses in front of it, and the longus colli muscle lies behind.

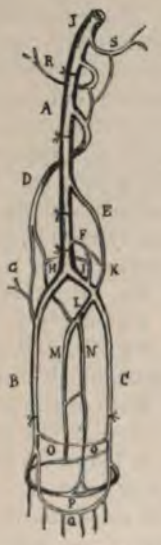


FIG. 164.—Diagram to show the collateral circulation after ligature of the axillary brachial and radial and ulnar arteries. A. Brachial; B. Radial; C. Ulnar; D. Superior profunda; E. Inferior profunda; F. Anastomotica magna; G. Radial recurrent; H. Interosseous recurrent; I. Anterior and K. posterior ulnar recurrent; J. Axillary; L. Common interosseous; M. Posterior interosseous; N. Anterior interosseous; OO. Anterior and posterior carpal; P. Deep palmar arch; Q. Superficial palmar arch; R. Posterior circumflex; S. Subscapular.

The vertebral artery has required ligature for a wound or traumatic aneurysm. It is exposed by an incision along the posterior border of the sterno-mastoid, which is drawn forwards with the vessels, or the incision is made at the anterior border and the muscle drawn outwards with the great vessels in their common sheath. The artery is sought for in the groove between the scalenus anticus externally and the longus colli internally under the prevertebral fascia, and is tied with its vein before it enters the sixth transverse process or between this and the fifth one.

The axillary artery requires to be ligatured in continuity for a wound or rupture (p. 401). In the third part of its course it can be readily secured by raising the arm and making an incision through the skin and deep fascia along the inner border of the coraco-brachialis and biceps. In the first part of its course it may be reached by an incision parallel to and just below the clavicle, the pectoral muscles being retracted downwards or the fibres partly split; or if the wound is in the second part, the pectoral must be cut across. Owing to the depth of the first and second part, ligature of the third part of the subclavian is to be preferred for axillary aneurysm. The collateral circulation (Figs. 162 and 164) after ligature of the first portion of the axillary is carried on by the same vessels as after ligature of the third part of the subclavian. After ligature of the third part of the axillary it is carried on chiefly by the anastomosis of small branches of the subscapular and circumflex above with similar branches of the superior profunda below.

The brachial artery may be *compressed* by the fingers whilst the thumb grasps the outer side of the arm. It may require

ligature for—1, wound of the artery; 2, aneurysm at the bend of the elbow; 3, wound of the palmar arch.

To tie the brachial artery in the arm, do not let the back of the arm so rest that the triceps (see Fig. 165) is pushed forwards, and the artery then displaced, or the triceps may be thus mistaken for the biceps, the ulnar nerve for the median, and a large inferior profunda artery for a small brachial. Make an incision (Fig. 166, *c*) along the

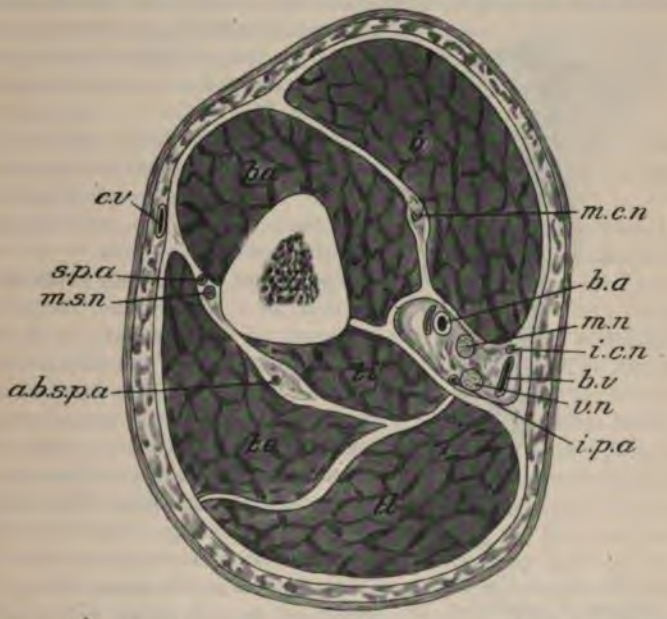


FIG. 165.—Section through the arm below the middle to show the relations of the brachial artery. (After Braune and Esmarch and Kowalzig.) Muscles: *b.* biceps; *ba.* brachialis anticus; *te.* external head of triceps; *tl.* long head of triceps; *ti.* inner head of triceps. Vessels: *b.a.* brachial artery with vena comes; *i.p.a.* inferior profunda artery; *s.p.a.* superior profunda artery; *a.b.s.p.a.* articular branch of the superior profunda artery; *b.v.* basilic vein; *c.v.* cephalic vein. Nerves: *m.n.* median nerve; *i.c.n.* internal cutaneous nerve; *u.n.* ulnar nerve; *m.c.n.* musculo cutaneous-nerve; *m.s.n.* musculo-spiral nerve.

inner edge of the biceps in a line drawn from the anterior fold of the axilla to the middle of the bend of the elbow through the integuments and deep fascia, avoiding the basilic vein which lies over the course of the artery beneath the skin. The median nerve crosses the artery along the middle of its course from without inwards, and during life may receive a communicated pulsation until drawn aside. The artery is carefully separated from the venæ comites surrounding it.

To tie the artery at the bend of the elbow, make the incision

obliquely from within outwards (Fig. 166, *d*), avoiding the basilic vein, and divide the semilunar fascia of the biceps; the artery will be found between the tendon of the biceps on the outer side and the median nerve on the inner side. A high bifurcation of the brachial may be met with. The *collateral* circulation when the artery is tied above the origin of the superior profunda is the same as after ligature of the third part of the axillary. When tied below the superior profunda, it is chiefly carried on by the anastomosis of this vessel with the radial and interosseous recurrent, and the anastomotica magna; when tied below the inferior profunda, by the additional anastomosis of this vessel with the posterior ulnar recurrent (see Fig. 164).

Fig. 166.—Lines of incision for ligature of arteries of the upper extremity.

The *superior profunda* may be injured and a traumatic aneurysm form in its course in the musculo-spiral groove, or as it runs between the supinator longus and the brachialis anticus.

The **radial and ulnar arteries** may be tied for—1, a wound or traumatic aneurysm of either vessel; or, 2, wound of the palmar arch; but it is a question whether ligature of the brachial is not preferable in the latter case at some distance from the septic wound. Both arteries are more easily *tied at the wrist*, where they are superficial (Fig. 236), and can be felt pulsating. The *radial* lies between the supinator longus and the flexor carpi radialis; the *ulnar* between the innermost tendon of the flexor sublimis digitorum and the flexor carpi ulnaris, by which latter tendon it is slightly overlapped. An incision about an inch long through the integuments and deep fascia parallel to the course of either vessel, is all that is necessary to expose them (Fig. 166, *g*, *h*). In the case of the ulnar, however, the flexor carpi ulnaris may have to be held aside. The aneurysm needle should be passed from the ulnar to the radial side to avoid the nerve which lies to the ulnar side. In the case of the radial, the needle may be passed either way as the radial nerve at the wrist is not in contact with the artery. No harm will ensue if the venæ comites are tied with their respective vessels. *The radial artery in the upper third* lies deeply between the supinator longus and pronator radii teres. Make an incision (Fig. 166, *e*) in a line drawn from the middle of the bend of the elbow to half an inch internal to the styloid process of the radius. Separate the muscles and the artery will be exposed. The radial nerve in this situation is some distance to the outer side of the

artery. *Ligature of the ulnar in the upper third* is more difficult, as it lies beneath the superficial flexor muscles. Make an incision (Fig. 166, *f*) four inches long in a line drawn from the front of the internal condyle to the radial side of the pisiform bone. Seek the interval between the flexor carpi ulnaris and the flexor sublimis digitorum. Separate these muscles, and the ulnar nerve will be seen. The nerve approaches the artery to the inner side about the junction of the upper and middle third of the forearm. Seek external to the nerve, and the artery will be found between the flexor sublimis and flexor profundus digitorum. The *collateral circulation* after ligature of the radial and ulnar arteries is by the anterior and posterior interosseous arteries to the carpal branches (see Fig. 164).

To *compress* the radial and ulnar, the fingers grasp the back of the forearm, whilst the thumbs press on the line of the arteries just above the wrist.

Palmar arteries.—The *termination of the radial artery* may be tied in the triangle on the dorsal aspect formed by the extensors of the thumb; superficial to the triangle is a branch of the radial vein and of the radial nerve. Exceptionally the radial artery runs superficially over the supinator longus and extensores ossis metacarpi and primi internodii, before dipping into the triangle. The line of the *superficial palmar arch* is marked by a line slightly convex downwards drawn from the pisiform bone towards the palmar border of the fully outstretched thumb, whilst *the deep palmar arch* is about a quarter to half an inch above this. From the superficial arch are given off the digital branches which divide for the supply of the fingers about half an inch above the clefts. From the deep arch are given off the interosseous branches which run deeply between the metacarpal bones, also the princeps pollicis to the thumb and radialis indicis to the radial side of the index finger. Such directions should serve as a guide when a ligature is required for hæmorrhage from wounds of the palm, which should be sufficiently enlarged for the purpose. It is much more efficient and does much less harm than attempts to control by pressure.

The abdominal aorta may be *compressed* to check post-partum hæmorrhage or during amputation of the hip. The simplest plan to keep up pressure for any time is to press with the closed fist using the weight of the body, and to do this whilst standing on a stool and keeping the elbow fully extended. Lister's tourniquet is also employed (see Fig. 157, p. 391) by first compressing the artery with fingers just below and to the left of the umbilicus until all pulsation is lost in the groins, then applying the pad to replace the fingers and holding it firmly whilst the tourniquet is being screwed up, which should be done only just sufficiently to stop pulsation below. Fatal injury has been done to the pancreas, solar plexus, intestines, or sac of an aneurysm by this means.

The abdominal aorta below the origin of the renals can be *ligatured* in some animals, as Sir Astley Cooper showed in the dog. In rabbits with a thin abdominal wall, rigidity and paresis of the hind limbs result. Sir Astley Cooper applied a ligature on the abdominal aorta of a man for a leaking iliac aneurysm; others have followed him. No paraplegia ensues. The attempts have been nearly successful. The anastomosis is through the internal mammary, the intercostal and lumbar arteries above, into the deep epigastric and circumflex iliac arteries below.

The common iliac has been ligatured many times successfully. It may be done for aneurysm involving the external or internal iliacs and for hæmorrhage into a pelvic abscess. A median incision is made in the hypogastrium, the pelvis raised, the intestines pushed aside, the ureter as it crosses the lower end of the artery behind the peritoneum is made out and avoided. The peritoneum is divided, the artery exposed, and the needle passed away from the corresponding vein, on the right side from without inwards, on the left from within outwards. It may be difficult to reach the artery and to avoid the vein on account of œdematous subperitoneal fat. The anastomotic circulation comes from the opposite side, also from the internal mammary, intercostals, and lumbars, into the deep epigastric and circumflex iliac.

The internal iliac has been ligatured as a preliminary to operating upon a vascular tumour or aneurysm of the buttock and to removing the uterus. The operation is the same as for the common iliac, the bifurcation of which is made out and then the internal iliac is tied just below and on the inner side of the brim of the pelvis.

The external iliac may require ligature for (1) aneurysm in the groin, (2) wound of the vessel, (3) secondary hæmorrhage from the femoral. A line drawn from half an inch below and a little to the left of the umbilicus to the middle of Poupart's ligament marks its course. For aneurysm the *transperitoneal* ligature as described for the common iliac is preferred by some as less likely to injure the sac of the aneurysm or the circumflex iliac anastomosis, the artery being secured just below its origin. The median incision is better than Abernethy's in the line of the vessel as keeping clear of the aneurysm and not injuring the deep epigastric anastomosis.

The *extra-peritoneal* operation was always used when the opening of the peritoneal cavity was dreaded. It is the better operation when there is room for the ligature without approaching too near the sac of the aneurysm. Make a curved iliac incision, beginning a little external to the centre of Poupart's ligament upwards and outwards for about three inches towards the anterior superior spine of the ilium. Divide the skin, superficial and deep fascia, and the aponeurosis of the external oblique; cut more carefully through the internal oblique and transversalis muscles, and the fascia transversalis will be exposed. Divide this on a director

taking care not to injure the peritoneum. Separate the peritoneum gently from the psoas muscle, and let an assistant press it carefully upwards and inwards. The artery will now be felt beating at the inner part of the wound along the inner border of the psoas. Pass the aneurysm needle from within outwards to avoid injuring the vein which lies to the inner side of the artery. The small crural branch of the genito-crural nerve lies on the artery, and the circumflex iliac vein and vas deferens cross it just before it passes under Poupart's ligament. The *chief accidents* that may occur during ligature are:—1, Injury of the peritoneum; 2, wound of the vein; 3, wound of the spermatic cord; 4, wound of the epigastric artery; 5, puncture of the circumflex iliac vein; and 6, rupture of the aneurysmal sac. The *chief dangers* after ligature are:—1, Gangrene of the limb; 2, peritonitis; 3, secondary hæmorrhage. Should secondary hæmorrhage occur, carefully applied pressure must be tried. If this fails, nothing is left but to ligature the common and internal iliac by the transperitoneal method; and if the hæmorrhage continues from the distal end, the common femoral and deep epigastric as well. The *collateral circulation* (Fig. 167) is carried on chiefly by the anastomosis between the internal mammary and deep epigastric; the ilio-lumbar and circumflex iliac; the gluteal and external circumflex; the obturator and internal circumflex; the sciatic and the superior perforating and internal circumflex.

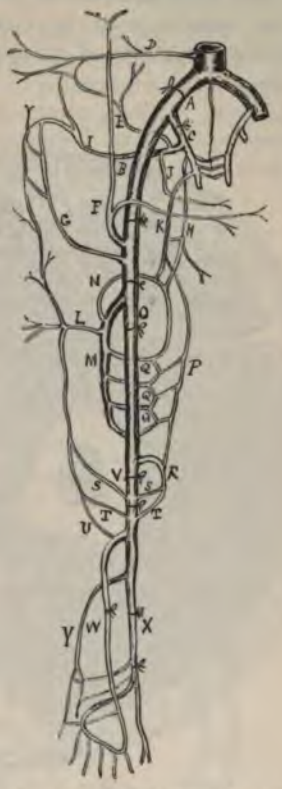


FIG. 167.—Diagram of the collateral circulation after ligature of the common iliac, external and internal iliac, femoral, popliteal, and arteries of the leg. A. Common iliac; B. External iliac; C. Internal iliac; D. Last lumbar; E. Ilio-lumbar; F. Epigastric; G. Circumflex iliac; H. Obturator; I. Gluteal; J. Lateral sacral; K. Sciatic; L. External circumflex; M. Profunda; N. Internal circumflex; O. Femoral; P. Comes ischiatici; QQQ. Perforating; R. Anastomotica magna; SS. Superior articular; TT. Inferior articular; U. Tibial recurrent; V. Popliteal; W. Anterior tibial; X. Posterior tibial; Y. Peroneal.

The common femoral artery may be *ligatured* for (1) aneurysm in Scarpa's triangle, (2) wound, or (3) secondary hæmorrhage. It

The *chief dangers* after ligature are—1, gangrene; 2, secondary hæmorrhage; 3, phlebitis and pyæmia from pricking the vein. The *collateral circulation* (Fig. 167) is carried on by the anastomosis of (*a*) the perforating branches of the profunda with the articular branches of the popliteal; (*b*) the descending branch of the external circumflex with the external articular branches of the popliteal and tibial recurrent; and (*c*) the artery of the great sciatic nerve with the internal articular branches of the popliteal.

The popliteal artery may be ligatured *in its upper part* for popliteal aneurysm. Place the limb on its outer side and make an incision about four inches in length upwards from half an inch above the adductor tubercle parallel to and just behind the tendon of the adductor magnus. Divide the deep fascia, avoid the long saphenous vein and nerve, retract the sartorius backwards and adductor magnus tendon forwards. Draw the semi-membranosus backwards and inwards, and feel for the pulsation of the vessel at the inner margin of the semi-membranosus. Hook the nerve outwards or inwards, and open the sheath well to its inner side to avoid the vein. Here the artery, as shown by museum specimens, is generally healthy a little above the aneurysm.

The popliteal artery may also require to be ligatured behind the knee for (1) wound, (2) aneurysm treated by the direct method. The patient being turned over and the leg extended, an incision is made a little external to the middle line of the popliteal space to avoid the short or external saphenous vein. Then the internal popliteal nerve is met with rather to the inner side of the middle line and is retracted. The popliteal vein is next sought for in the fat, with care not to wound it. It lies behind the artery and very closely adherent to it. Having been separated from the artery and drawn aside, the artery is found on the bone. The *collateral circulation* is through the anastomotic branch of the superficial femoral, the articular branches of the popliteal arising above the ligature, and the terminations of the profunda artery, into the tibial branches (see Fig. 167).

The posterior tibial artery (see Fig. 170).—*In the upper third.* Place the limb on its outer side, and make an incision four inches long parallel, and half an inch posterior, to the inner border of the tibia (Fig. 169, *e*). Divide only the skin and superficial fascia in the first incision to avoid injuring the long saphenous vein. Then divide the deep fascia and draw the gastrocnemius, if seen, backwards; cut through the tibial origin of the soleus, and the intermuscular fascia will be exposed. Divide this carefully, and the artery will be found lying on the tibialis posticus with the posterior tibial nerve to its inner side. Ligature of the posterior tibial in its upper third can hardly be required, except for a wound which should then be enlarged longitudinally until sufficient room is obtained. *At the ankle.*—Make a curved incision over the artery

a finger's breadth behind and below the internal malleolus. Divide the superficial and deep fascia and the internal annular ligament, and the artery will be found between the tendons of the flexor longus digitorum and flexor longus hallucis with the nerve to its outer side. For *Collateral circulation*, see Fig. 167.

A continuation of this incision will expose the *internal and external plantar branches.*

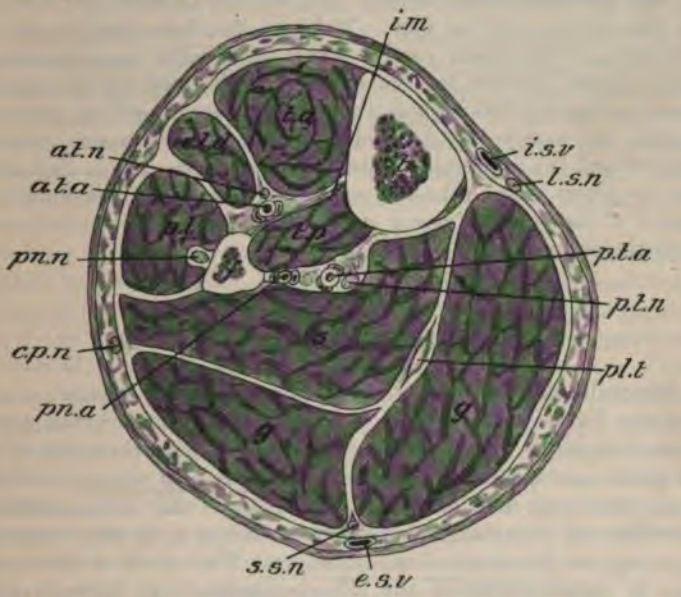


Fig. 170.—Section through the middle of the leg to show the relation of the vessels. (After Braune and Esmarch and Kowalzig.) *f.* Femur; *t.* tibia; *i m.* interosseous membrane. Muscles: *t.a.* tibialis anticus; *e.l.d.* extensor longus digitorum; *p.l.* peroneus longus; *t.p.* tibialis posticus; *s.* soleus; *g, g.* gastrocnemius; *pl.t.* plantaris. Vessels: *a.t.a.* anterior tibial artery with venæ comites; *p.t.a.* posterior tibial artery; *pn.a.* peroneal artery; *i.s.v, e.s.v.* internal and external saphenous vein. Nerves: *a.t.n.* anterior tibial nerve; *pn.n.* peroneal nerve; *p.t.n.* posterior tibial nerve; *l.s.n.* long saphenous nerve; *s.s.n.* short saphenous nerve.

The anterior tibial artery (see Fig. 170.)—A line drawn from the inner side of the head of the fibula to midway between the two malleoli indicates the course of the vessel. *In the upper third* make an incision about five inches long in the line of the artery (Fig. 169, *c*) through the skin and superficial fascia, and look for the innermost white line, which indicates the cellular interval between the tibialis anticus and the extensor longus digitorum. Divide the deep fascia over this line on a director; hold the muscles apart by retractors, and the artery will be found on the interosseous membrane with the nerve to its outer side. *In the middle third* the artery lies between

the tibialis anticus and extensor proprius hallucis, and the nerve lies on the artery. *In the lower third* the artery lies between the extensor proprius hallucis and the extensor longus digitorum with the nerve on its outer side. An incision in the line of the artery (Fig. 169, *d*) and the separation of the muscles is all that is necessary to expose the vessel in either of these situations. For *Collateral circulation*, see Fig. 167.

The dorsalis pedis artery may require ligature for a wound on the dorsum of the foot. Walsham has twice seen it tied for aneurysm of the vessel itself. Make an incision in a line drawn from midway between the two malleoli to the interval between the great and second toes; divide the skin and the superficial and deep fascia: the artery will be found between the extensor proprius hallucis and the innermost tendon of the extensor longus digitorum. As the artery sinks into the sole it is crossed by the innermost tendon of the extensor brevis digitorum. The anterior tibial nerve is on the outer side.

DISEASES OF THE VEINS.

Thrombosis, or clotting of the blood in a vein, is very common and was formerly thought to be always the result of inflammation of the vein-wall. Hence, whenever a vein became thrombosed, the condition was spoken of as phlebitis. It is now known, however, that a thrombus may form in a vein without any inflammation of its walls, and that the presence of a thrombus is in some cases the cause and not the result of inflammation. *The causes* of thrombosis may be considered under the following heads:—1. *Changes in the vein-wall*, such as may result from injury, rupturing the inner coat, inflammation, and degenerative processes, and such as often exist in the inner coat in varix. 2. *Changes in the blood*, such as occur in septicæmia and pyæmia and other affections in which there is a destruction of the white corpuscles, and the consequent setting free of the fibrin ferment contained in them, connected with the formation of clot, or similar to arterio-sclerosis. 3. *The presence of micro-organisms.* 4. *The retardation or arrest of the blood-stream*, as (*a*) when a ligature is applied to a vein; (*b*) when a vein is compressed by a tight bandage, tumour, or contraction of a cicatrix; (*c*) when the blood flows feebly through a vein owing to weak action of the heart induced by age, fevers, loss of blood, or a varicose condition of the vein. 5. *The presence of a foreign body not covered by endothelium*, as a piece of ligature, an embolus, an already formed thrombus, or the protrusion of a new growth into the lumen of a vein.

Method of extension of the thrombus.—When once formed the thrombus may extend either with or against the blood stream. As a rule, however, it takes the former direction, extending from

the smaller to the larger veins, and in this way may at times reach the heart.

Appearances of a recent thrombus.—When the blood is at rest at the time of coagulation, as when a vein is ligatured, the thrombus will be red throughout, as both the coloured and colourless corpuscles equally become entangled in the fibrin. It will fill the whole lumen of the vein, and at first will be soft and gelatinous, and but loosely attached to the vein-wall. When, on the other hand, the clot is formed gradually whilst the blood is in motion, as when the clot is deposited on an unhealthy vein-wall, it is laminated, and firmly adherent to the wall, and will be either pale or tinged with red, according to the rate at which it is formed. A post-mortem clot may be distinguished from the above in that it does not adhere to the wall of the vessel, nor as a rule entirely fill its lumen. It is never laminated, although it may consist of two layers, one pale and one red.

Changes in the thrombus.—1. The clot may become converted, together with that portion of the vein in which it is contained, into a fibrous cord. Thus it first loses its red colour from the disappearance of the red corpuscles, then becomes firmer, more adherent to the wall of the vein, and finally indistinguishable from it. The minute changes which occur in this process are similar to those already described in the healing of an artery after injury (p. 210). 2. The clot may undergo calcification and become converted into a so-called *vein-stone* or *phlebolith*, which may either be found free, or attached to the walls by a pedicle. 3. The clot may soften and disintegrate, forming a pultaceous reddish material or a yellowish-red puriform fluid, the latter change being probably due to the action of septic micro-organisms. 4. The clot may shrink to one side of the vein, or become tunnelled by the blood, or it may be slowly carried away by the circulation without causing any mischief. The tunnelling or canalisation of the clot is brought about by the gradual enlargement of the small vessels which normally permeate the clot during its conversion into a fibrous cord.

The effects of thrombosis are—1. *Swelling and œdema* of the parts from which the affected vein returned the venous blood. This may completely or partially disappear, or it may remain permanent constituting the condition known as *solid œdema*, according to whether the lumen of the vein is or is not restored or the collateral channels are sufficient for the requirements of the circulation. A good example of œdema from thrombosis is furnished by the so-called white leg, or *phlegmasia alba dolens*, so common after parturition as the result of the extension of the clot from the uterine veins through the iliacs to the femoral. 2. *Gangrene* occasionally occurs after the plugging of a large vein where the collateral circulation is insufficient to relieve the engorgement of the part, and is necessarily of the moist variety. 3. *Phlebitis*, or inflammation of the

vein-walls, may ensue, and will take a simple or a spreading and suppurative form, according as the thrombus is of a simple or of a septic or infective nature. 4. *Embolism*, owing to a portion of a thrombus being swept away by the blood stream and becoming lodged in a distant vessel. The way in which this detachment may take place is shown in Fig. 13, p. 55. If the thrombus is of a simple character, no harm may ensue; but if septic the embolus will also be infective, and set up a like inflammation in the part where it becomes arrested. (See *Embolism*, *Pyæmia*.)

Signs.—When the deep veins are plugged, the only evidence of the thrombosis will be signs of obstruction to the circulation in the veins below, such as œdema or dilatation of the superficial veins with deep-seated pain. When, however, a superficial vein, as one of the saphenas, is affected, there will be a hard cord-like swelling in the situation of the vein, and tenderness on pressure and a feeling of stiffness on movement or marked pain. Should inflammation of the vein follow from the presence of the thrombus, there will be in addition some heat and redness of the skin. (See *Phlebitis*.)

Treatment.—Absolute rest in the recumbent position is essential, lest a portion of the clot should become detached and lodged in an important organ, as the brain, or plug the pulmonary artery, and sudden death ensue. Where there is much œdema, the part should at first be elevated, and subsequently, after the danger of detachment of the clot has passed, evenly and firmly bandaged.

Phlebitis, or inflammation of veins, may be divided into the simple, and the septic, infective or spreading.

Simple phlebitis, formerly known as *adhesive phlebitis*, is a simple local inflammation of the vein-wall, and may terminate in resolution or obliteration of the lumen of the vein, or increased fibrous thickening of the wall with irregular dilatation and increase in length, so that the vein becomes tortuous. *Causes.*—1. Injury of the vein-walls. 2. Simple inflammation of the surrounding tissues. 3. The formation of a non-infective thrombus in a vein. 4. Gout or the gouty diathesis. 5. As a sequel of typhoid fever.

Pathology.—The walls of the vein become infiltrated with leucocytes and swollen, whilst a thrombus, should such not already be present as the cause of the inflammation, will form in the interior of the vein. Changes similar to those already described under *Hæmorrhage* may then occur in the clot. Thus the vein may become obliterated by a fibrous cord, or the thrombus may be absorbed and the calibre of the vein restored. Or pyogenic organisms may gain admission and suppuration may take place. The suppuration, however, does not spread unless the thrombus, the barrier to the organisms, is disturbed on the evacuation of the pus.

Symptoms.—There is the same cord-like swelling in the affected part of the vein as in simple thrombosis, also the skin, at least

when a superficial vein is involved, is dusky red and œdematous, and pain is severe on pressure and on movement. When a vein of large size is affected, there will be in addition signs of obstruction to the venous circulation. The gouty form is either associated with ordinary gouty inflammation in the foot or joints, or occurs with little or no evident provocation in persons of marked gouty constitution or with a gouty inheritance. It is more especially characterised by its symmetry, apparent metastasis, and frequent recurrences.

The treatment is similar to that of thrombosis. Where there is much pain, a mixture of glycerine and belladonna may be smeared over the vein, or lead and opium lotion, or hot boric fomentations may be applied. Should an abscess form, it must be opened with antiseptic precautions, care being taken not to disturb the clots. Saline purgatives should be given, with potash, lithia, piperazine, and colchicum in the gouty, and the patient placed on low diet.

Septic, infective, or suppurative phlebitis, is a spreading, infective inflammation of the vein-walls and tissues around. *Causes.*—It is due to an infective inflammation spreading to the vein-walls, or to the softening of an infective thrombus. Thus it is frequently met with in connection with compound fractures, ill-conditioned stumps, acute osteomyelitis, diffuse cellulitis, malignant pustule, facial carbuncle, etc. It may also follow the opening of an abscess, the result of simple phlebitis, if the clots are disturbed and septic processes are allowed to take place in the wound. *Pathology.*—The coats of the inflamed vein become red, swollen, and in places soft and diffluent, and the thrombus softened into a purulent fluid, whilst micrococci are found both in it and in the vein-walls. These changes gradually extend up the vein and should portions of the infective thrombus be carried away by the blood stream, metastatic abscesses in distant parts and general blood poisoning will result (*pyæmia*). *Symptoms.*—When a superficial vein is affected there is at first a cord-like swelling as in simple phlebitis, but the redness and œdema of the skin and subcutaneous tissue are more marked, followed by fluctuation in one or more situations in the course of the vein, and frequently by general blood-poisoning. When the deep veins are involved, the disease may not be suspected until signs of pyæmia set in, and the condition of the veins can then only with certainty be ascertained on a post-mortem examination being made. The *treatment* follows upon the diagnosis of the septic condition from which the suppurative phlebitis starts. (*a*) Thorough search for, and removal if possible of the primary cause, *e.g.*, abscess and necrosis of bones; (*b*) the cutting down upon the septic thrombus and washing it out from the vein, placing a ligature, when necessary, above and below. If this treatment is not carried out early the limb may have to be amputated

to save life. When the vein is superficial, the inflamed portion may be dissected out after a ligature has been applied above and below.

Varicose veins.—A vein is said to be varicose when it is permanently and unequally dilated and its coats have undergone certain degenerative changes. A varicose condition is most common in the veins of the lower extremities, and in the veins of the rectum and testicle (see *Piles and Varicocele*).

The *causes* may be considered under the heads of increased intravenous pressure, and changes in the vein-walls. A. *Increased intravenous pressure* may be due to—1. Organic affections of the heart whereby the return of venous blood is impeded. 2. Obstruction to the circulation in the portal system, a cause chiefly affecting the hæmorrhoidal veins (see *Piles*), in the inferior vena cava or iliacs after thrombosis. 3. Pressure upon the veins, such as may be exerted (*a*) by the gravid uterus or a tumour of the uterus or of the ovaries on the iliac veins; (*b*) by an aneurysm of the abdominal aorta on the inferior vena cava; (*c*) by fæcal accumulation on the hæmorrhoidal veins; (*d*) by a tumour in the groin on the femoral vein; (*e*) by an ill-fitting truss on the spermatic veins (see *Varicocele*); or (*f*) by a tight garter on the saphenous veins. 4. Long standing, which has a tendency to cause the accumulation of blood in the veins of the lower extremity. 5. Severe muscular exertion, whereby an increased amount of blood is driven by the contraction of the muscles from the deep into the superficial veins. Some authors maintain that the pressure of the blood first produces a dilatation of the superficial veins where the intermuscular veins empty into them; that this dilatation being frequently repeated becomes permanent; that the valves in consequence are unable to close and protect the veins, and being thrown out of use gradually undergo atrophy, whilst the weight of the column of blood, from the inefficiency of the valves, becomes further increased, and the veins still further dilated. B. *Changes in the vein-walls.*—These may consist (1) in an hereditary weakness and want of muscular tone, whereby the veins readily dilate and undergo inflammatory softening of the walls. (2) a proliferation of the cells composing the vein-wall, by which it is irregularly increased in length and in lumen. *Occurrence.*—Varicose veins are more common in men than in women, owing to their more frequent exposure to the exciting causes. Women, however, are peculiarly liable to them during pregnancy.

Pathology.—A varicose vein is lengthened, dilated, and frequently tortuous (Fig. 171), the dilatation being especially marked where the intermuscular veins open into the superficial, and at the situation of the valves. The middle, and to a less extent the outer coat, are often greatly thickened by the formation of fibrous tissue, but the inner coat shows little change. In the dilated portions immediately

above the valves the coats, on the other hand, may be found greatly thinned, so that the vein may give way at these situations. The valves themselves, from the dilatation of the veins, cease to be of service, and become atrophied, being frequently reduced to mere ridges or fibrous cords. Thus the intravenous pressure in the segment below is increased as the column of blood in the upper part of the vein is no longer supported by the valves. The deep veins are generally involved in the varicose condition, and the smaller radicals returning the blood to the varicose vein from the skin often share in the dilatation. The skin, in consequence of the obstruction to the venous return, becomes congested and chronically inflamed (*varicose eczema*) and frequently gives way, producing an ulcer (*varicose ulcer*); whilst at times the pressure of the vein causes thinning of the skin, and this, with the wall of the vein, may yield, and hæmorrhage result. When the valves have been destroyed, the hæmorrhage may be very severe, and even terminate in death if the limb is allowed to hang down, or a partly tight band constricts the limb above, as the blood sometimes flows backwards from the heart through the proximal end as well as from the distal end of the vein. Thrombosis at some part of the vein is of frequent occurrence.

FIG. 171.—Varicose saphenous vein. The upper dark line marks the incision just below the saphenous opening, the lower one permits of excision of the internal saphenous, also of the external near its termination, and of any communications.

The *symptoms* usually complained of are fatigue and a sense of fulness of the limb after exercise or long standing, and perhaps cramp, coldness of the feet, swelling and œdema of the ankle, and numbness of the leg. Sometimes there is deep-seated pain. The tortuous vein or veins meandering up the leg is a characteristic sign which cannot be mistaken (Fig. 171). When the smaller radicals are affected bluish clusters of minute veins are visible here and there, especially about the ankle and knee. Pulmonary embolism may occur.

The *treatment* may be palliative or radical. *Palliative treatment*

consists locally in supporting the dilated vein by an elastic stocking or by a Martin's or an ordinary bandage, and reducing the hours of standing where possible. The bowels at the same time should be regulated, and the general health improved by tonics, iron, etc. *Radical treatment* should be undertaken under the following circumstances:—1, when a vein appears likely to burst; 2, when there is a knotted mass of large veins in one or more situations giving rise to much pain and inconvenience; 3, when an intractable ulcer is present: and 4, when the varicosity is chiefly confined to a single vein. Many methods of operating have been proposed, some highly dangerous. With modern antiseptic precautions, the *excision* of a portion of the vein after a ligature has been applied above and below is the best and most certain method of radical cure. A small incision is made over the vein, the vein neatly dissected out for an inch or two, a ligature applied as high up and a second as low down as possible within this limit, the vein between the ligatures excised, and the little wound carefully united by sutures. Several similar incisions may be made along the course of the varicose vein. Of late years excision of an inch or so of the saphenous vein just below its entrance into the femoral has been much practised, but it is not quite devoid of danger, since alarming symptoms from slight pulmonary embolism have occurred. This method is successful very often in curing the varicose veins in the leg without further measures. Some require removal at the same time, especially from the leg, where there is a large communication with the external saphenous. When a mass of tortuous veins is the source of trouble, it should be dissected out, ligatures having been previously applied to the larger veins leading to and from the mass. When the trouble chiefly consists in a diffuse dilatation of venules in the skin, an incision should be made transversely through them down to the deep fascia, clamping and tying the cut veins on either side, then suturing. After the operation the patient should be kept at rest in the recumbent position, to prevent a portion of the thrombus becoming detached and the consequent danger of embolism in vital organs; whilst the strictest precautions should be taken to keep the wound aseptic, lest suppurative phlebitis ensue.

Ligature of special veins.—*Axillary vein.*—This vein is exposed throughout its length in the removal of malignant disease of the breast including the axillary glands. Its complete occlusion must be avoided whenever possible on account of the persistent œdema of the arm which is likely to follow. In the case of septic inflammation with obstruction to anastomosing channels, moist gangrene of the arm may occur. Hence careful ligature of venous branches a little before their junction with the main vein, or the application of a lateral ligature or suture, if necessary, should be the rule. Its cut end is tied in amputation at the shoulder-joint.

The *subclavian vein* is exposed in ligature of the subclavian and in

excision of the clavicle, to which the same remarks apply as in the case of the axillary. Its ligature is necessary in amputation of the upper extremity.

External jugular vein.—In its course from the angle of the jaw downwards and outwards across the sterno-mastoid to the outer border of that muscle it has often to be divided, after first applying clamp forceps, *e.g.*, in excising tuberculous glands. From it blood is taken to relieve an over-distended right side of the heart (see *Venesection* below).

Internal jugular vein.—The complete occlusion of this vein by ligature is not generally dangerous; exceptionally fatal venous congestion of the brain on the same side has occurred owing to the opposite internal jugular being abnormally small or already blocked. Hence there should be definite indications for this operation, and whenever possible ligature of branches before the junction, or lateral ligatures or sutures should be employed.

The vessel is also exposed in the removal of malignant and tuberculous glands, goitre, etc., and is ligatured to prevent septic absorption from the ear. Malignant glands and tuberculous glands may often be dissected off the vein. If the vein is involved, then a healthy piece above and below should be first exposed and ligatured before the diseased section is removed.

Profuse and even fatal hæmorrhage may occur during an operation, or be secondary owing to the wall having become so diseased that no ligature will hold. A strip of iodoform gauze must be pushed firmly upwards towards the jugular foramen, and the blood being under low pressure, the hæmorrhage will be arrested, and a few inches of the strip being drawn out every day, in four or five days a granulating wound will be left.

To attempt the arrest of septic absorption in lateral sinus thrombosis, the vein is exposed by an incision in the line between the sterno-clavicular articulation and the mastoid process, and the vein carefully separated. Then a ligature is applied to the end nearest the heart, if possible below the level of thrombosis, the vein cut through above the ligature, and the ligature ends cut off. The exposed vein above is drawn forwards and fixed in the upper angle of the wound, which is protected from contamination by a gauze plug. Then the upper end is opened and the breaking-down clot removed, so that fluid can be syringed through from the sinus. If there be no thrombus and bleeding follows, the upper end must remain clamped for some hours until thrombosis has occurred. The wound in the neck is kept filled with gauze to prevent septic infiltration. This operation does not always stop the septic absorption, which may continue to pass downwards by pharyngeal veins.

Veins of the lower extremity.—Of the main veins, the *iliac* and *popliteal* may be ligatured for wounds, and if no septic inflammation causes obstruction, no danger need ensue. Yet ligature of these

veins should be avoided if possible to escape the œdema of the limb which follows when it is dependent.

The common femoral is ligatured at a great risk of gangrene. In wounds of Scarpa's triangle two of the three veins, *the superficial femoral* or *the deep femoral* or *the saphenous* may be ligatured successfully, yet not without danger, especially as in such cases some septic inflammation is hardly to be avoided.

The *long saphenous vein* is ligatured in its line drawn from the inner condyle to the saphenous opening, and can generally be seen through the skin when dilated, except in very fat people. It should be well separated for one to two inches, and this piece excised between two ligatures. There is often a large branch coming over the adductors from the inner side of the thigh which must be included in the ligation.

The *external or short saphenous* vein is often dilated, and communicates with the varicosities on the long saphenous. In such a case the foregoing ligature of the long saphenous will prove insufficient.

Fig. 172.—Method of holding the lancet in bleeding. (Heath's Minor Surgery.)

The vein will be seen dilated when the patient stands up, and a piece must be excised just below its entrance into the popliteal space. Any communication with the internal saphenous should be ligatured at the same time.

Venesection or phlebotomy.—*Bleeding* is not often employed in modern medicine, and not at all in surgery. It is sometimes used for very acute pneumonia with cyanosis in young and plethoric subjects, also from the external jugular to afford temporary relief from congestion to the right side of the heart, and perhaps occasionally in cerebral apoplexy when the pulse-tension is very high.

Venesection at the bend of the elbow.—The skin is rendered aseptic, a narrow bandage or broad tape is carried twice round the arm a little above the elbow, and the ends fixed for the time in front by a single bow drawn just tight enough to obstruct the superficial veins. Selecting generally the median basilic vein and grasping the elbow with the left hand whilst steadying the vein with the thumb, an ordinary sterile scalpel is made to puncture the distended vein and to cut out so as to incise the skin for half an inch in the long

axis of the arm, *i.e.*, a little obliquely to the course of the vein, care being taken not to penetrate deeper. The blood is directed into a graduated bleeding bowl until about 10 ozs. has been lost. The old plan was to have the patient sitting upright and let blood flow until he became faint after losing about a pint. The flow, if necessary, is increased by the patient grasping a stick, and is stopped by the surgeon's thumb. Over this a pad is slipped, the ends of the constricting band loosened, crossed over the pad, carried round behind the ulna, and the two ends finally knotted over the pad, so that the patient can bend the arm without loosening the dressing. By observing the above precautions, complications such as septic phlebitis or traumatic aneurysm are avoided.

Venesection in the neck.—The dilated external jugular is fixed with the thumb, punctured obliquely to its long axis, and the blood allowed to flow, whilst the thumb over the vein below compresses it, should the patient inspire deeply, lest air be drawn in. The wound may be closed by suture, hare-lip pin, or pad and strapping.

Saline venous infusion, see *Hæmorrhage*, p. 207.

TUMOURS OF BLOOD-VESSELS, HÆMANGIOMA, NÆVUS.

The capillary nævus or *plexiform angioma* consists of a mass of eccentrically dilated and tortuous capillaries (*telangiectasis*) bound together by a scanty amount of connective tissue. These nævi are most common on the head, neck, face and chest; sometimes, but by no means generally, they are in the lines of embryonic fissures, "fissural nævi," and occur as small, flat, or slightly-elevated, red or purplish-red patches on the skin or mucous membrane. Sometimes they are spread out as a thin reddish blue layer covering perhaps the greater part of one side of the face, and are then known as "port-wine marks," *nævus flammeus vel vinosus;* or they may form bluish-red warts or moles, *nævus verrucosus;* or nævi appear as small points with radiating vessels, "spider nævi." The blood can be pressed out momentarily, but returns when pressure is removed. Their rate of growth varies; sometimes it is quick, at other times it is slow; or they may remain stationary, or disappear spontaneously. They are congenital in origin, except the spider nævi, which often appear in later life as a superficial evidence of vascular changes.

Treatment.—The smaller nævi may readily be destroyed by nitric acid, or ethylate of sodium painted on daily, or by the galvano-cautery point. Those known as "port-wine marks" should be left alone, or under some conditions they may be scarified or tattooed to the colour of the skin. Vaccinating on a nævus is unreliable as such, and does not generally cure the nævus. Setons, the ligature method, and perchloride of iron should never be used. Absolute alcohol (1 to 3 cm.), tincture of iodine, or pure carbolic acid may be injected in drops,

whilst applying pressure around. By far the best treatment is a careful excision.

The venous nævus or *cavernous angioma* consists of a number of cavernous spaces lined with endothelium and communicating with each other and with the arteries on the one hand and the veins on the other. These nævi form distinct tumours bound together by delicate connective tissue sometimes containing fat. The blood in them is of a dark venous colour. They are generally subcutaneous, but may likewise occur beneath a mucous membrane or in organs, especially the liver, or be widespread in a limb which is enlarged (*vascular elephantiasis*), or they may replace a muscle. They are always congenital. They appear as irregular, nodular, soft, compressible tumours, easily emptied by pressure, but quickly refilling, and swelling up on coughing or straining. When under a mucous membrane they are of a purplish-blue colour. The skin or mucous membrane covering them may be natural, or it may be affected with the capillary variety of nævus. Their favourite seats are the lips, cheeks, scalp, organs of generation, back, and nates. They may gradually increase in size, remain stationary, or undergo a spontaneous cure or a fibro-fatty degeneration, in which latter case they resemble a fatty tumour, and sometimes contain cysts in their interior.

Treatment.—The indications are to remove or to destroy the nævus with as little scarring as possible. This may be done, 1, by excision with the knife; or 2, by electrolysis. Coagulating injections and setons are highly dangerous, and should not be used. Ligature is painful, slow, and leaves a scar, and is seldom employed at the present day.

1. *Excision with the knife* is a rapid, painless, and effective method, and where, as in the lip, by removing a V-shaped piece a mere linear scar is left, is, perhaps, the best. To avoid hæmorrhage, however, the incision should be made wide of the growth.

2. *Electrolysis* is indicated when it is important to save the skin and reduce the scar to a minimum, as in venous nævi about the face. It consists in passing two or more needles into the nævus in different situations, and sending a weak constant current through them; or better, passing needles connected only with the negative pole of the battery into the nævus, and rubbing a rheophore connected with the positive pole over the skin of some other part of the body. Should bubbles of gas escape, the current must be reduced in strength. Before removing the needles from the nævus the current should be reversed for a few seconds in order that the coagulum formed around the needles may not be disturbed and bleeding from the punctures ensue. The operation must be repeated many times, as if too strong a current is used sloughing will take place.

A nævo-lipoma is a tumour consisting of fatty and nævoid tissue. It resembles a fatty tumour in that it is soft and lobulated,

and a nævus in that it may be made smaller by pressure and dilated veins may be seen or felt on its surface. It is less uniform in consistency, moreover, than a fatty tumour, and does not pulsate. Like a nævus, it is congenital in origin, and is practically always the cause of fatty tumours in children. It may develop in connection with a spina bifida, meningocele, encephalocele. A fatty tumour covered with nævoid skin in the middle line of the lumbar region is one form of spina bifida occulta. The fatty tumour may grow inside the spine or skull, and cause pressure. Free excision is the treatment.

Plexiform angioma or **arterial varix** is a dilated, tortuous, and irregularly-pouched condition of an artery similar to that of a vein in varix, and may occur in the artery of a limb, or in the carotid. A **cirsoid aneurysm,** or **aneurysm by anastomosis,** is a pulsating tumour composed of several lengthened, dilated and pouched arteries, or a localised dilatation of arteries, veins and capillaries, and is nearly always situated on the scalp. Cirsoid aneurysms are congenital in origin, and may be compared with the retia mirabilia met with in some animals. Beginning from a small patch they develop as if the pressure caused not only a dilatation, but a new growth of vessels by proliferation of cells; gradually the mass of dilated vessels forms a tumour, which tends to become dependent, to ulcerate, and to bleed. On the scalp, a cirsoid aneurysm is most common on the temporal, less common on the occipital artery.

Treatment is always by excision, beginning with a careful ligature of the vessels beyond the tumour, temporal, external carotid, etc.

DISEASES OF THE LYMPHATICS AND LYMPHATIC GLANDS.

Lymphangitis or inflammation of the lymphatic vessels is either acute, subacute or chronic, and generally associated with more or less inflammation of the lymphatic glands. *Causes.*—The most common primary cause is the absorption of infective products, especially streptococci from a wound, often very trivial, such as a simple scratch, abrasion, sting, or puncture ; or the organisms may enter by an abrasion of the skin, as a chafe of the heel, excessive friction, or sun-burn. *Pathology.*—The walls of the lymphatics become infiltrated with cells, swollen, and softened, whilst the endothelium is shed, and the lymph contained in the vessels may undergo coagulation. The inflammation spreads to the surrounding tissues, but seldom higher in the course of the lymphatics than the first set of glands, which also become swollen and infiltrated and arrest the further progress of the septic products. Lymphangitis may *terminate* in resolution, or in suppuration in and around the glands, or in or rarely around the lymphatics themselves. When very virulent the

septic products pass through the glands, and general blood-poisoning ensues. *Symptoms.*—In severe cases, lymphangitis generally begins with a chill or rigor, followed by high temperature and fever, and perhaps vomiting and diarrhœa. Red lines, when the superficial lymphatics are affected, are seen running from the wound to the nearest lymphatic glands, with here and there patches of redness. There is generally pain and tenderness, especially in the region of the swollen glands, and swelling and œdema, sometimes of the whole limb. It may be diagnosed from phlebitis by the redness being superficial and in the course of the lymphatics, not in the course of the veins, by the absence of the cord-like and knotty feel of plugged veins, and by the presence of glandular enlargement; from erysipelas by the redness having no defined margin, and generally running in lines. The *treatment* consists in disinfecting any wound or abrasion by antiseptics and placing the inflamed part at rest in an elevated position. Fresh extract of belladonna in glycerine or boric acid fomentations may be applied, and abscesses should be opened as soon as they appear. If any swelling is left, pressure in the form of Scott's dressing or ammoniacum and mercury plaster may be used to disperse it.

The chief causes of subacute and chronic lymphangitis are tubercle, syphilis, and in the tropics filariasis.

Lymphadenitis, or inflammation of the lymphatic glands, may be acute, subacute, or chronic.

Acute and subacute lymphadenitis is nearly always secondary to inflammation of the parts from which the afferent lymphatics proceed. Indeed, in most inflammations, there is some tenderness of the neighbouring glands. Occasionally, however, the glands in the groin or axilla become enlarged without any discoverable irritation within the area from which they receive their lymph. In such cases there is generally a history of a strain, as from lifting heavy weights, or of over-exertion, as from a long walk. The explanation is probably the engorgement of the gland with lymph in the case of a strain from rupture of some of the efferent lymphatics, or in the case of over-exertion by more lymph being pumped into the gland from the muscular interspaces than can escape by the efferent vessels. The lymphatic vessels themselves, although the glands may become extensively involved, and even suppurate, often escape. The inflammation, however, rarely proceeds further in the course of the lymphatics than the first series of lymphatic glands, although it often spreads to the surrounding tissues (*peri-lymphadenitis*). The changes in the inflamed gland are like those of other inflammations. The whole gland is enlarged, the vessels being dilated and the lymph-sinuses crowded with cells Micro-organisms, similar to those found in the inflammatory lesion giving rise to the lymphadenitis, are discovered in the glands. The *signs* are tenderness, heat, pain, and swelling, followed by redness of

the skin and œdema. The gland, at first moveable, becomes fixed, and if the process runs on into suppuration, the usual signs of an abscess ensue. Familiar examples of lymphadenitis are seen in the bubo of gonorrhœa and soft chancre, in the tender glands of erysipelas, and in the suppuration under the jaw caused by a carious tooth. The *treatment* consists in subduing the inflammation of the part from which the lymphatics proceed, painting the glands with belladonna and glycerine, applying boric acid fomentations, and, if suppuration has occurred, in making a free incision. If suppuration threatens, the glands may be dissected out.

Acute lymphadenitis of the neck without suppuration (Dawson Williams).—After a period of incubation of about a week the deep cervical glands, three or four in number, along the anterior border of the sterno-mastoid, form an acute swelling. The swelling begins generally on the left side and passing to the right, reaches its maximum in two or three days, and then begins to subside.

It attacks young children one after the other in the same household, without any special inflammation of the fauces or pharynx, is attended by febrile symptoms, constipation, and sometimes by albuminuria or even hæmaturia, but by no rash. Other glands, posterior cervical, axillary, inguinal, mesenteric and the spleen, may also swell, but they all tend to subside without suppuration, although the child remains anæmic and in poor health for a month or two.

Lymphadenitis occurs in many specific fevers, *e.g.*, at the nape of the neck in German measles. Hæmorrhagic lymphangitis is a characteristic feature of plague.

Chronic lymphadenitis may be tuberculous or syphilitic.

Tuberculous lymphadenitis is very common in children, especially in the neck. The suppuration of the glands can frequently be traced to some concurrent cause, as the irritation of pediculi on the head, eczematous affections about the mouth, enlarged tonsils, adenoids, or carious teeth. Where it depends upon the presence of the tubercle bacillus (see *Tubercle*, p. 87), the glands slowly enlarge, and become infiltrated with small round cells; whilst in the tuberculous foci non-vascular areas containing giant-cells, lymphoid corpuscles, and tubercle bacilli are found. The enlargement may subside by the formation of sound fibrous tissue, or the inflammatory products may caseate, and suppuration occur in or around the gland; at times, the caseous mass may dry up and become cretaceous, or shrinkage or fibroid and fatty degeneration may ensue. In relatively rare instances only does the tubercle become disseminated, leading to general tuberculosis. Sometimes the first change in the gland is a diffuse endothelial proliferation, not tending at first to form tuberculous foci nor to caseate, although this ultimately occurs. Thus at first the masses resemble lymphadenoma, and are only to be distinguished by the inoculation of guinea-pigs. *Signs.*—The glands are affected, and become enlarged without pain. They are at first

distinct and moveable, but later often coalesce and become adherent to the surrounding parts. After a time, they may soften and break down; the skin then becomes adherent and red, gives way, and a curdy pus is exuded. After the abscess has thus opened, a portion of the broken-down gland may be seen in the floor of the ulcer, the edges of which are bluish-pink and undermined. (See *Tuberculous Ulcers.*) The ulcers are very indolent, and when finally healed, leave characteristic raised, puckered, pinkish-white scars. Concomitant signs of tubercle are frequently present. *Treatment.*—Any source of irritation, such as pediculi, carious teeth, etc., should be sought and removed, and the patient, if tuberculous, treated as indicated at p. 93. Tuberculous glands, if they do not rapidly subside under general treatment, should be removed, since much less deformity is produced by the single linear scar, which in time becomes almost imperceptible, than by the puckered scar which results when the glands are allowed to suppurate and burst spontaneously. If an abscess has already formed, it should be opened early to minimise scarring. This may be done by a small incision, after which the capsule of the gland may be cleared out by a Volkmann's spoon. Should an indolent ulcer or sinus remain, as often happens if the abscess is allowed to burst spontaneously, it should also be scraped with a Volkmann's spoon and its edges cut away.

Syphilitic lymphadenitis occurs in the glands receiving lymphatics from the place of the primary sore; it also occurs as a general enlargement in the secondary period, the glands at the back of the neck being especially affected. Such glands may remain enlarged and harden by fibrous tissue. Occasionally, not frequently, a gumma forms in them.

Elephantiasis is a name which has been applied in the past to various affections, arising from different conditions in which the skin and subcutaneous tissues of the extremities undergo marked enlargement, and the surface becomes nodular and rugose, more or less like the hide of an elephant.

Elephantiasis is the term now especially applied to the disease called *elephantiasis arabum*, and known to be the result of filariasis (see *Filaria*, p. 114, and *Elephantiasis scroti*). *Elephantiasis græcorum* is the name formerly applied to one of the phases of leprosy now recognised to be the work of the leprosy bacillus.

Congenital elephantiasis is due to a vascular dilatation of a diffuse cavernous hæmangioma, or a lymphatic obstruction, a diffuse lymphangioma arising as an abnormality in development. Subsequently malignant disease may ensue.

Acquired elephantiasis, non-filarial in origin, may be due to involvement of lymphatic trunks by inflammation, pelvic, appendicular, etc., or to the pressure of tumours or scars, especially from burns, or to infiltrating malignant disease, or it may be due to the wounding or the excision of main lymphatics.

The *treatment* of such enlargements consists in elevation, carefully elastic bandaging from the extremity upwards, massage, especially after the limb has been fomented with hot water. If complications such as are mentioned under *Tropical Elephantiasis, Chronic Ulcers of the Leg*, come on it may be proper to amputate.

Lymphangiectasis or **lymphatic varix** is a dilatation of the main lymphatic channels analogous to that occurring in veins. The lymphatics are dilated, thick-walled, tortuous and filled with lymph or chyle. They may appear simply as tortuous masses with normal skin like varicose veins, without the blue colour, or the skin may undergo the changes described below. The *congenital* form arises in countries outside the tropics, and is rare, the *acquired tropical* form is due to filaria.

Lymphatic varix is met with in the spermatic cord, where it resembles the ordinary varicocele. Or it may occur as patches on the superficial lymphatics of the limbs, and is then subject to recurrent attacks of inflammation causing a steady increase. *Treatment.*—The mass should be completely dissected out.

Lymphadenocele.—Lymphatic glands are enlarged to form a lobular mass surrounded by inflammatory tissue, and occupied by multilocular cysts filled with lymph or chyle. The cause is mainly filarial, affecting the inguinal and femoral glands of young men. They increase by recurring attacks of inflammation and may rupture on to the surface.

Treatment.—Rest and gentle pressure by bandaging. Some patients recover even in an infected area as they grow older. If not, and if elephantiasis threatens, the dilated lymphatics should be dissected out. As mentioned before, Dr. Manson and Mr. Godlee have tried to make an anastomosis with the superficial veins so that the chyle may get into the circulation instead of passing by the thoracic duct—which is blocked—in this way imitating the natural process of cure.

Lymphangioma is a tumour composed of lymph-spaces in the skin and subcutaneous tissue dilated into cysts, and separated by fibrous tissue which may become very vascular. It is of congenital origin. It should be dissected out.

Lymphatic nævus may appear on the tongue, lips, or skin as a strawberry-like mass composed of small cysts about the size of mustard seeds, some clear yellow being filled with lymph, some blue from extravasated blood, some bright red little aneurysms through which the blood is flowing. Between the cysts are red points of capillary loops in the vascular connective tissue. The cysts may rupture and discharge lymph or chyle which dries as crusts, or the lymphangiomatous process extends more deeply and widely.

Lymphatic warts or *lymphangioma hypertrophicum* are the little soft red lobulated warts which are found on the skin. They consist of masses of endothelial cells ranged somewhat in columns vertical

to the surface, and covered by normal epidermis (Fig. 173). Some have hair follicles and pigment forming hairy moles. Smaller patches and discolourations of the skin form freckles or lentigines, and sunburns or ephelides.

Lymphangioma cavernosum vel cystoides (Fig. 174) is the diffuse form of dilatation of lymphatic spaces, affecting sub-epithelial and intermuscular connective tissue. The mass on section appears honeycomb-like, the cysts are dilated lymphatic spaces containing lymph or extravasated blood, the intercystic tissue is a very vascular, soft, almost myxomatous fibrous tissue containing groups and masses of lymphadenoid tissue; in the lip the condition causes the diffuse

FIG. 173.—Lymphangioma hypertrophicum. Photograph of a section through a soft red congenital wart removed from the skin of the loin of a man aged 24. Exactly symmetrically on the opposite side a previously similar wart had become the seat of a sarcoma.

hypertrophy called *macrocheilia*, in the tongue *macroglossia*, in the neck, and exceptionally in the kidney or inguinal region, *hygroma*, in the limb *elephantiasis*. All lymphangiomas are subject, without obvious cause, to recurring attacks of inflammation. Whilst still limited this inflammation may cause the whole mass to undergo absorption, as happens sometimes in hygroma of the neck; or the effect of each inflammation is to leave behind a further enlargement, as in the case of the tongue or limb, gradually producing an important deformity; or the lymphatic spaces may burst and form a discharge on the skin, through which organisms may enter and set up diffuse suppurative lymphangitis. Finally, as congenital structures they are liable to malignant changes, endothelioma, lympho-sarcoma.

Lymphorrhœa.—Lymphatic vesicles bursting on the skin continue

to discharge lymph which, drying, produces crusts, and from decomposition, ulceration. When the thoracic duct is obstructed, the flow may consist of chyle. The continuous loss of albuminous and fatty fluid may be an important means of exhausting the patient. (For Chyluria, etc., see *Filariasis*, p. 114).

Lymphadenoma or **Lymphoma** is an enlargement of the lymphatic glands, consisting of a simple hypertrophy of lymphadenoid tissue, closely resembling the normal, but there is not so well defined a distinction between the cortical and medullary portions, and in some cases there is a marked increase in the fibrous stroma. One or two glands only may be affected, especially the glands in the posterior

Fig. 174.—Lymphangioma cavernosum. Photograph of a section through the subcutaneous tissue of the thigh of a child affected with congenital elephantiasis, who at the age of four died of lympho-sarcoma.

triangle of the neck, on one or both sides. Or with the above there may be masses in the axilla or groin, and further still the disease may be generalised, involving lymphadenoid structures widely—general lymphadenoma or lymphadenomatosis, or Hodgkin's disease. The spleen, thymus, mediastinal or retro-mesenteric glands, the conjunctiva, naso-pharynx, tonsils, and the Peyer's patches of the intestine, as well as the bone-marrow, may be involved. Lymphadenoma may occur in combination with leucocythæmia, an increase of white corpuscles in the blood, and with anæmia, a diminution of hæmoglobin in each red corpuscle, or a diminution in the number of the red cells also.

Lymphadenoma has been classed hitherto as a non-inflammatory affection, but it is a disease closely allied to tuberculosis, with which

it may be found post-mortem, or be easily confused with, especially when tuberculosis attacks lymphatic glands diffusely without going on to caseation. Moreover, the origin of lymphadenoma can often be traced to some local source of irritation, from the conjunctiva, naso-pharynx, mouth, larynx, hand, genital organs.

Signs.—The glands enlarge, but at first remain free and distinct, later forming smooth, oval, elastic and generally painless swellings, which do not tend to soften and suppurate or to set up periadenitis, but weld together to form a doughy mass. The general health is affected by leucocythæmia or acute anæmia, or by the local pressure of these masses on the blood-vessels or respiratory tract.

Lymphadenoma, besides its origin in the normal lymphadenomatous tissues, viz., lymphatic glands, thymus, spleen, bone-marrow, naso-pharynx and Peyer's patches, is also seen occasionally in the skin, when it is generally multiple; also in the breast and testicle, when it is usually bilateral.

Diagnosis.—From tubercle lymphadenoma is distinguished by the absence of caseation and suppuration and of tubercles on microscopical examination. From lympho-sarcoma there is no sharp line of demarcation, in fact lymphadenoma, unless cured by medical or surgical measures, tends in time to become lympho-sarcoma. According to Mr. Butlin and Dr. Andrewes true lymphadenoma should have on section a homogeneous whitish appearance with little streaks or splotches of blood, like brain or cow's udder. On microscopical examination there is seen an increase of the fibrous tissue framework, and of the endothelial cells, with a marked diminution of the small round cells or lymphocytes. This appearance should distinguish lymphadenoma from lymphosarcoma and from inflammatory hypertrophy. *Treatment.*—The excision of all enlarged glands whenever practicable is usually desirable. For widespread disease arsenic in increasing doses and iodide of potassium is often successful for a time, but the disease is apt to recur if the local masses which appear to be the starting-point of the infection are not excised. The doses of arsenic may have to be gradually increased up to a drachm or more of Fowler's solution, but must be stopped on the slightest sign of neuritis or pigmentation. The iodide may be given in large doses or be applied locally.

Lympho-sarcoma is the term used for small-round-celled sarcoma. Usually it arises in lymphatic glands or in lymphadenoid tissues, but it may occur also in the skin and other organs (see p. 130). From lymphadenoma the only clinical distinction is the failure of arsenic and iodide of potassium to arrest progress. *Treatment.*—Excision whenever practicable.

DISEASES OF SPECIAL LYMPHATIC GLANDS.

Glands of the neck.—*The submental glands*, one on either side of the middle line, enlarge from irritation of the lower lip, anterior part of lower jaw, anterior third of tongue and corresponding part of the floor of the mouth. A median vertical incision may be used for their removal.

The submaxillary glands enlarge from irritation of the face, nose, side of mouth and the middle of the tongue. They may be reached by a curved incision and are more or less fused with the submaxillary salivary gland, some lymphadenoid lobules being within its capsule, the removal of which will entail a ligature of the facial artery on the proximal and distal side.

The pre-auricular gland receives from the forehead, eye, orbit and upper face. It is removed by a vertical incision, avoiding the temporal artery.

The post-auricular gland is connected with the auricle, middle ear and the scalp around. The vertical incision to remove it should lie well under the shadow of the auricle.

The post-cervical glands form a suboccipital and superficial set in the posterior triangle along the external jugular vein, and receive lymph especially from the scalp. They can be removed by an incision along the posterior border of the sterno-mastoid, with ligature of the external jugular.

The supra-clavicular glands in the subclavian triangle are continuous with the post-cervical and with the axillary glands. They are removed by a horizontal incision above the clavicle.

The deep cervical glands, also called sterno-mastoid, jugular, and carotid glands, form a chain from the mastoid process downwards, to be continuous with the glands of the mediastinum. One of the most important, the carotid gland *par excellence*, lies over the bifurcation of the carotid behind the thyroid cartilage, and is early enlarged in cancer of the tongue. They receive from all the other glands of the neck, directly also from the back of the tongue, pharynx and larynx, and are continuous with the mediastinal glands.

Besides the local removals mentioned above, wider dissections are often necessary, as follows.

Dissection of tuberculous glands.—When the post-cervical glands are chiefly infected, but also to some extent the submaxillary and subclavian, or even the deep cervical, these may be all exposed by the Z-shaped incision of Senn, or this incision in limited cases can be only partially made. The incision commences below and a little to one side of the chin, and is carried across below the mastoid process over the sterno-mastoid, then down the posterior edge of the sterno-mastoid nearly to the clavicle and across the supra-clavicular fossa to end over the trapezius. One flap is turned forwards and downwards, the other backwards and upwards. There is thus

exposed a parallelogram, and by drawing the sterno-mastoid forwards the jugular vein is clearly in view throughout its length, and so can be avoided, also the spinal accessory and nerves of the brachial plexus, whilst all hæmorrhage is under control. By drawing the upper part of the sterno-mastoid backwards the submaxillary triangle is cleared out, and either from in front or behind the muscle the deep cervical glands are removed down to the clavicle. The sterno-mastoid need not as a rule be divided. The wound being sutured, healing often occurs by first intention, or any discharge easily escapes from one of the posterior angles, whilst the resulting scar is largely out of sight or in natural folds.

Dissection of malignant glands from the neck.—Here it is necessary to dissect especially the anterior triangle, and to remove all the deep cervical glands from the mastoid process to the clavicle. An incision is made along the whole length of the anterior border of the sterno-mastoid, and this is met by another from the chin at the level of the thyroid cartilage. One skin flap is turned up over the jaw, another inwards and downwards. The platysma and deep fascia are dissected up, branches of the external jugular, thyroid, lingual, and facial veins are secured, also the facial artery on the proximal and distal side of the submaxillary salivary gland, which is included in the removal, except as regards its duct. The hypoglossal nerve is avoided, unless the tongue is being removed. Then the deep cervical glands are carefully dissected off the internal jugular and carotid from the mastoid process down to the clavicle, all vessels being clamped before division. After tying the vessels the skin is united. When there is a communication with the mouth, a drain is placed where the two incisions join.

Glands in the axilla.—The lymphatic glands in the axilla are infected locally, or from the upper extremity or from the breast by septic, tuberculous or malignant disease. They are a source of pain from irritation of smaller nerve branches and from pressure on the nerve trunks.

A superficial follicular abscess begins in the hair follicles and sebaceous glands from dirt and sweat, rubbing of the clothes, also in patients who are in bad health. *A deep abscess* forms in the arm-pit, secondary to a septic wound or disease of the neighbouring bones or shoulder joint.

Tuberculous disease may develop in the axillary glands without any obvious cause, or be secondary to such disease in the hand or breast.

Subacute and chronic enlargement follow vaccinia inoculations whether on the arm or on the nipple of a nursing mother whose child has been recently vaccinated. The enlargement may be due to syphilis following a sore on the finger of a medical practitioner or midwife, or on the nipple of a woman who has put a syphilitic child, not her own, to the breast.

Lymphadenoma forms a soft, painless, doughy mass, not tending to suppurate.

Malignant infection is most frequently derived from the breast, but may come from the limb, from an epithelioma of the hand, or from a rapidly-growing periosteal sarcoma.

Treatment.—For an abscess the arm is abducted as far as possible and an incision made through the skin midway between the axillary folds, this spot being usually the most prominent part of the swelling. Then forceps are thrust in, followed by a tube, but only a very limited breaking down of loculi with the finger should be produced, lest hæmorrhage ensue requiring painful plugging.

For *excision* of the enlarged glands along with a breast cancer, see *Cancer of the breast.* To remove enlarged glands from the axilla alone, abduct the arm as much as possible, make an incision along the anterior axillary fold and a cross cut downwards to the angle of the scapula, and follow the course described under *Breast.* Afterwards the skin is sutured except where a drainage-tube is put in, or if septic the whole cavity is filled with gauze.

The supra-trochlear gland receives lymphatics from an area of distribution corresponding to that of the ulnar nerve. Its enlargement may be distinguished from a tumour on that nerve by being fixed and pressure not giving rise to tingling in the fourth and little finger. A joint-cyst in that situation can be felt to be connected with the elbow-joint, and to become more or less tense according as the elbow is extended or flexed. A hæmatoma from a ruptured varicose vein is more superficial and attached to the skin. An abscess is laid open or the enlarged gland excised by a longitudinal incision.

Glands in the groin.—*The femoral* chain of glands are infected chiefly from the foot and leg, but also from the skin of the scrotum near the junction with the thigh. It is rather by recent and small sources of infection than through large areas of old standing ulceration that an abscess arises. Hence it may be a slight blister, crack, etc., on the foot, at first overlooked, which is the source. If the glands are swelling from a chronic ulcer it may indicate the onset of malignant disease. Both epithelioma and acute periosteal sarcoma cause malignant infiltration. The glands lying between the superficial and deep fascia have some mobility in the early stages of enlargement, except as regards the gland in the saphenous opening. Enlargements have to be distinguished from a hernia, varix of the saphenous vein, aneurysm, or swelling in connection with the hip.

The inguinal glands are enlarged in *venereal affections* of the penis, urethra, and scrotum, especially the most internal gland of the chain. But also the irritation may come from the skin as high as the umbilicus, and from the anus or buttock. Next to venereal disease, *parasites* are the most common cause. *Strain and intertrigo* may also cause an enlargement, which, however, does not

suppurate. *Tuberculous disease* rarely originates in the superficial glands of the groin, but may follow an ulcer, *e.g.*, tuberculous inoculation of a circumcision wound.

The iliac glands are infected by disease confined to the testis, also by extension from the superficial set.

Treatment.—Incision of an abscess or bubo. It is better to anæsthetise the patient so that a free incision can be made, and the cavity wiped out, by which means the formation of a troublesome sinus may be avoided. Generally speaking, the incision for the femoral glands is made vertically, that for the inguinal parallel to Poupart's ligament. Some advise the latter to be vertical over the most internal gland of the set when made without a general anæsthetic, so that the wound may gape when the patient stands or walks, but this is more likely to result in a sinus. The patient should be lying down for the incision.

A sinus has to be excised, or at least fully slit up, well scraped, and dressed with gauze. Occasionally abscess and ulceration go on with great rapidity, and extend into the blood-vessels. The prognosis is then bad, owing to ligatures not holding on the sloughing vessels. The wound is swabbed out with a strong antiseptic, iodoform dusted on, and the wound dressed with gauze, pressure being meanwhile kept up on the external iliac. *After* (not before) the disinfection of the wound, the external iliac artery may be ligatured by the extra-peritoneal method.

An indolent mass of glands may be due to *gummatous disease*, and diminish under mercurial ointment locally and iodides internally, or be lymphadenomatous, and then large doses of arsenic may be successful. But *malignant lympho-sarcoma* may also appear, and quickly involve the vessels.

The glands in the groin are *excised* by a T-shaped incision, a vertical incision in the line of the femoral artery and a cross incision parallel to Poupart's ligament. All the glands, with the superficial fascia and fat, are then dissected from the deep fascia towards the saphenous opening, where the vein must be excised between two ligatures, and numerous branches of the common femoral tied near their origin. All this dissection requires great care not to injure the main artery and vein, which, if involved, had better be left untouched, lest gangrene follow the excision.

Popliteal lymphatic glands.—They receive lymph from such a limited area, viz., the back of the heel and calf, that a neglected blister on the heel is the usual cause of their enlargement and of the production of an *abscess*. But suppuration in the popliteal space may also be caused by disease of the knee-joint or bones. In obscure cases an abscess must be distinguished from an inflamed popliteal aneurysm by controlling the circulation above and exploring with caution, avoiding any injury to the vein.

DISEASES OF NERVES.

Neuritis and neuralgia.—*Neuralgia* simply means nerve-pain, and is dependent, in most of the forms with which surgery deals, upon neuritis, especially if infiltration by malignant disease be included.

When *neuritis* commences in the sheath of the nerve it may be termed *perineuritis;* or when it affects the connective tissue amongst the nerve fibres, *interstitial neuritis;* or both, *adventitial neuritis.* When inflammation affects the nerve fibres themselves it may be called *parenchymatous neuritis* or *degenerative neuritis*, or simply *secondary inflammatory degeneration.* Special forms of neuritis are *ascending neuritis*, when the inflammation spreads up the nerve; *local*, when affecting one, or *multiple*, affecting many nerves, or *peripheral neuritis* when affecting nerves near their termination.

Causes of neuritis.—A. Local: (1) Injury, as wounds, contusions, compression, or strains; (2) Cold affecting a superficial nerve, often termed "rheumatic"; (3) Extension of inflammation: the cerebro-spinal nerves by extension from inflammation of the meninges; nerves near joints by suppuration, or from a bedsore; the intercostal nerves by extension from an inflamed pleura; from veins affected by phlebitis. B. General: (1) Toxins—diphtheria, alcohol, typhoid fever, influenza, gout, rheumatism, malaria; (2) Metallic blood poisons, lead, arsenic; (3) Infiltration by special disease, syphilis, tubercle, leprosy, cancer.

Pathology.—Local neuritis is generally adventitial, affecting the nerve sheath and the connective tissue between the superficial bundles. If acute, the nerve is red from dilatation of its small vessels, and swollen from infiltration of leucocytes between the nerve fibres. In chronic inflammation the sheath is thickened, more adherent, and the outer zone of the nerve shows increase of fibrous tissue with degeneration of fibres. When the nerve is in a bony or fibrous canal and cannot swell, pressure is exercised upon the deeper bundles of fibres, and hence function is easily disturbed or lost. The changes in the fibres following inflammation is that of *degeneration* similar to that described under *Injury* (see p. 280). The middle of the nerve is least affected, and the change stops just above the limit of the inflammation. In syphilitic neuritis along with simple neuritis a definite gummatous mass may form. In cancer there is much interstitial neuritis surrounding the actual infiltration of the cancer cells, which gradually replace the nerve. In leucocythæmia the nerves are infiltrated with white cells.

Symptoms.—The nerve, if superficial, may be felt to be swollen, tender on pressure. There is pain, burning, boring or darting, intermittent or continuous, with paroxysms. It is generally worse at night, is increased by movement, or by posture causing increased pressure or temporary congestion. Reflex disturbances, increased

sweating or muscular spasm may occur. When the nerve is compressed or in process of being destroyed, there is tingling, numbness or loss of sensation, also muscular paralysis and wasting. If many nerves are affected there may be some fever. The pain frequently radiates, is not limited to the nerve but extends to the whole limb, even to the bone, or the skin is hyperæsthetic. Trophic changes in the skin may occur, such as herpes, or the degenerative changes, glossy skin, pigmentary changes, changes in the hair, effusion into joints, followed by adhesions. The neuritis may ascend to the plexus from which the nerve proceeds, or to the spinal cord itself; or the opposite nerve may be involved by "sympathetic neuritis." It is supposed that referred pain can start a vasomotor disturbance, and so neuritis.

Treatment.—(1) The cause should if possible be sought for locally and removed, *e.g.*, a foreign body, spiculum of bone or decayed tooth, scar or callus following a wound or fracture, etc.; or when a general cause it may be prevented from acting, or may be removed by drugs, *e.g.*, iodide of potassium and mercury for syphilitic neuritis, quinine for malarial neuritis, iron and arsenic or phosphorus for anæmia.

(2) The relief of pain is most thorough under the use of opium or by injecting morphine with atropin, either subcutaneously or into the nerve, but there are grave objections to a continued use of such remedies; also chloroform vapour may be used for paroxysmal attacks, or phenacetin. Bromide of potassium is most generally given, also aconite, gelsemium, croton chloral, cannabis indica, nitro-glycerine.

(3) Locally the pain may be relieved by extract of belladonna or opium fomentations, by liniments of chloroform and aconite, by blistering or the actual cautery (spinal neuralgia), by the application of a strong Faradic current, or by stroking a weak constant current, which gently stimulates, over the nerve. Or percussion of the nerve may do good, presumably by promoting absorption of diseased products. The effect of *x* rays or electric baths may be tried.

(4) Destructive agents, such as pure carbolic acid or 1 per cent. osmic acid, injected in drop doses, have been recommended for sensory nerve twigs, such as those of the fifth. On a motor nerve they might cause undue paralysis.

(5) Nerve-stretching by temporarily paralysing a nerve is supposed to have a beneficial effect locally by freeing the nerve from adhesion to its sheath, and to give temporary rest to cells on the proximal side, so that by the time the nerves begin again to conduct afferent impulses, the nerve cells have recovered their normal tone.

(6) Neurectomy, the excision of a portion of the nerve, the cut ends being afterwards re-united, is indicated when a limited portion of a nerve has been destroyed by disease; it is also employed for the removal of the bulbous ends of nerves after amputation.

(7) Nerve extraction, or avulsion, neurexaresis, consists in drawing out a nerve from its nerve centre by slow traction, so as to prevent any possibility of restoration of conductivity.

(8) Excision of a ganglion.—This is indicated when the disease has already spread so far that the symptoms persist after stretching, excising, or tearing out nerves.

FORMS OF NEURALGIA.

Trigeminal neuralgia—Neuralgia affecting branches of the fifth nerve.—The more severe and intractable forms of trigeminal neuralgia with which surgery is called upon to deal is a disease of late life, occurring in patients about or over sixty, and frequently in old women. It appears to be an ascending neuritis, beginning in some peripheral branch in consequence of irritation, and gradually ascending to the Gasserian ganglion, or in other cases affecting from the beginning the Gasserian ganglion itself. It is marked by paroxysms of pain, accompanied by muscular twitchings and spasms, when it is known as tic douloureux, or when the attacks are of short duration and of an excruciating character, as epileptiform tic or neuralgia.

The cause can sometimes be traced to local irritation in the mouth, nose, or accessory sinus, the orbit, or bony foramina; to attacks of cold, influenza, and other causes of neuritis; or thirdly, to senile debility, which interacts with the pain, the one increasing the other, *e.g.*, by causing the gums and jaw to be so tender that the patient cannot masticate. The failure of medical remedies, exhaustion of the patient, unhinging of the patient's mind disposing him towards suicide, are indications for surgical measures. It is of great importance that all local sources of irritation be excluded; in the mouth, decayed teeth or bone; in the nose, stenosis, or polypi; in an accessory nasal sinus, suppuration; and in the eye, errors of refraction. Also specific medical remedies for syphilis, malaria, etc., should first have a trial.

Surgical treatment consists in *nerve stretching*, or better *avulsion* of those branches of the fifth nerve which are the most painful, and the skin over which is the most hyperæsthetic; and failing relief by these means, the *removal of the Gasserian ganglion*. This seems a better course than at once to proceed to attack the ganglion, a severe operation reported to have a mortality of about 20 per cent.

A. **First division.**—(*a*) *Supra-orbital neuralgia*, also called "brow ague," from its frequent connection with malaria. The pain radiates from the supra-orbital notch over the anterior half of the head, there being a painful spot on the nerve immediately above the notch. The pain felt in this nerve may be due to a diseased frontal sinus. Having excluded such cause the nerve may be exposed by a short horizontal incision just above the notch, which can usually be felt. The nerve is raised on a hook and one inch excised, or gradually

drawn on by the hook, or by rolling it over the jaws of a pair of clamp forceps until the proximal end is drawn out.

(*b*) *Ocular neuralgia.*—When the pain is seated in the eyeball, errors of refraction, especially hypermetropia, rheumatic inflammation or anæmia, should be first considered. Such methods of treatment failing, the *ophthalmic division* may be sought for through a horizontal incision in the upper lid, immediately below the eyebrow. Having cut through the orbicularis and attachment of the lid, the supra-orbital branch should be traced, by depressing the levator palpebræ with the eyeball, through the fat under the roof of the

Fig. 175.—Diagram showing lines of incision in the surgical treatment of trigeminal neuralgia. *a*. Infra-orbital for exposing the infra-orbital terminations of the second division of the fifth nerve; the interrupted continuation, the incision for the second division of the fifth nerve. *b*. Temporal, marking the flap raised in exposing the Gasserian ganglion. *c*. Pre-auricular, the incision for the auriculo-temporal nerve. *d*. Below the lobule, the oblique incision for the facial nerve. *e*. Behind the angle of the jaw, the incision for exposing the lingual and inferior dental nerves by the extra-buccal operation.

orbit, until the ophthalmic division is found, and the nerve drawn out from the sphenoidal fissure. The eyeball requires special protection.

B. **Second division.**—*Infra-orbital neuralgia.*—Special pain may be felt over the exit of the nerve, down the side of the nose, over the malar bone, or in the teeth or gums of the upper jaw. It is most necessary to exclude irritation from carious teeth, stumps and dead bone, empyema of the maxillary antrum, polypi or necrosis of bone in the nose. These causes being excluded, the *infra-orbital nerve* may be exposed by a horizontal incision just below the border of the orbit, in a line drawn between the supra-orbital notch and the division between the bicuspid teeth (Fig. 175, *a*). The skin, orbicularis palpebrarum, and levator labii superioris being divided,

the nerve is drawn out, or it may first be followed back a little distance by cutting away the roof of the canal in order to get a better hold.

The second division may be removed at the foramen rotundum. (*a*) *Through the antrum* (Carnochan's operation).—This is a dissection in which a head mirror or electric lamp is required. The upper lip is strongly retracted, the buccal mucous membrane divided, and the front wall of the antrum opened. A T-shaped incision has been made on the face, but a well-marked scar remains visible. From within the antrum the infra-orbital nerve may be followed back, a bright electric light causing the nerve to glisten through the back wall, which is chipped away. Meckel's ganglion lying in the fat of the spheno-maxillary fossa and the nerves emerging from the foramen rotundum are thus met with. Walsham has successfully performed this operation several times without inflammatory complications; in particular no harm happens to the eye.

(*b*) *Through the malar region.*—The incision for exposing the infra-orbital foramen is extended outwards over the malar bone to the zygoma (Fig. 175, *a*). The orbicularis is pushed upwards towards the orbit, the levator labii superioris and the masseter downwards; then the outer angle of the orbit, the malar bone and the malar process of the upper jaw are cut through and hooked upwards and outwards; next the infra-orbital nerve is traced backwards along the roof of the antrum, across the spheno-maxillary fossa to the foramen rotundum, where it is divided, and its distal palatine branches drawn out. Branches of the internal maxillary artery require ligation; the bone is replaced and the wound sutured.

C. **Third division.**—(*a*) *Inferior dental neuralgia.*—Special pain is felt over the end of the nerve as it emerges from the mental foramen. Pain in this nerve is most likely to be caused by some dental trouble, carious teeth or stumps, an outgrowth, an odontome on the root of an apparently sound tooth. When the pain appears to be a neuritis situated at the mental foramen, the nerve may be exposed there and drawn out, the incision being made in the line drawn from the supra-orbital notch through the division between the bicuspid teeth; the foramen looks forwards. It is reached by drawing down the lower lip and cutting through the mucous membrane. If further back, the nerve before it enters the lower jaw can also be exposed through the mouth. Walsham has many times stretched the nerve in this way, and can speak in the highest terms of the operation. The septic trouble, necroses, etc., to avoid which more elaborate operations have been undertaken, are myths. *Operation.*—Open the mouth with a gag, make an incision from the last molar tooth in the upper to the last molar tooth in the lower jaw; insert the finger between the internal pterygoid muscle and the bone, feel for the spine of bone at the entrance of the inferior dental foramen. Now pass a hook round the nerve, stretch and gradually

pull it out as much as possible. The wound heals in a few days without trouble, and the patient may be about his work within a week.

(*b*) *Lingual neuralgia.*—There may be intense neuralgia in the anterior two-thirds of half the tongue, so much so that the patient dare not move it to speak, masticate, or swallow his saliva. The mouth must be carefully examined to exclude a small epithelioma, *e.g.*, appearing as an indurated fissure in the region of the palatal fold. The tongue may be drawn out and to the opposite side, when the *lingual* nerve can be reached as it crosses the fold thus made tense between the tongue and the angle of the jaw, immediately beneath the mucous membrane ; or it is exposed as described above for the inferior dental nerve ; the lingual lies internal to the spine, the inferior dental nerve behind the spine.

Both the *inferior dental* and the *lingual nerves* may be exposed *by an external incision* curving behind the angle of the jaw (Fig. 175) from the facial artery to half an inch above the angle, beyond which the incision must not go deeper than the skin, or branches of the facial nerve will be divided. The masseter is then detached with a raspatory and the bone trephined, or the signoid notch deepened until the inferior dental foramen and the nerves are met with.

The *buccal nerve* which supplies sensation to the inner side of the mouth appears at the anterior border of the coronoid process on the fibres of the buccinator muscle. It has been reached from the mouth by cutting down upon the anterior border of the coronoid process through mucous membrane and muscle, or externally by a horizontal incision just above the parotid duct, below the zygoma and malar bone.

(*c*) *Temporal neuralgia.*—The pain is worse over the temple, or radiates towards the parietal eminence in the line of the auriculo-temporal nerve. Care must be taken to exclude trouble in the ear, whether due to a minor cause, such as wax or a foreign body in the meatus, or to some more extensive mischief. *The auriculo-temporal nerve* is found immediately behind the temporal artery, and is reached by a vertical incision from the level of the zygoma for 1½ inch upwards (Fig. 175, *c*).

Extracranial operation on the third and second divisions.—A flap of skin is turned upwards by an incision extending from the external angular process of the orbit downwards along the zygoma and upwards in front of the ear (Fig. 175, *b*), or downwards by an incision starting from the attachment of the auricle, across the temporal fossa to the middle of the malar bone. The zygoma is cut across in front of the ear and at its junction with the malar bone, the temporal fascia divided and the bone turned down with the masseter ; so pushing down the parotid duct and branches of the facial nerve. The temporal muscle may be also turned down from its attachment to the skull or raised by cutting across the coronoid process, or simply drawn backwards to reach the foramen rotundum, and forwards for

the foramen ovale. The external pterygoid is thus exposed and retracted, whilst the finger follows the great wing of the sphenoid down to the root of the pterygoid process. Close behind its sharp edge is the foramen ovale, and a little further forwards is the spur on the great wing of the sphenoid, and thus the foramen rotundum can be reached. One or both nerves can now be drawn out from the skull, and also their peripheral branches can be similarly treated. Branches of the internal maxillary artery require clamping and tying; there may be much venous hæmorrhage, to be checked only by firm pressure or even by breaking off the operation for a day or two.

Removal of the Gasserian ganglion.—Local or general causes of the pain being excluded, and the extraction of branches having failed to relieve, there remains the excision of the Gasserian ganglion, which has undoubtedly afforded permanent relief in some cases. The operation is a severe one, the mortality being about 20 per cent. from shock and septic inflammation. The indications for the operation are at present somewhat doubtful: if employed as a last resource, the patient being already exhausted, the mortality must needs be high; done early, it may be argued that the patient could possibly have been relieved by less severe measures.

The operation at present most generally used is the intracranial extradural method of Krause-Hartley. Mr. Rose's operation is mainly extracranial, as described above for the nerve divisions. Sir Victor Horsley employed an intradural method to divide the root of the fifth on the proximal side of the ganglion, but it appears to be too dangerous from shock and extravasation of blood.

The Krause-Hartley method.—A curved flap, including skin and muscle, is turned down from the temporal fossa above the zygoma extending from above the external auditory meatus to the external angular process of the orbit, then the squamous portion of the temporal bone is trephined and cut away. This flap has been modified by making it of the shape of the Greek capital Ω, so as to include skin, muscle, and bone. The bone is cut round by a circular saw, and the narrow part broken across or cut through with a Gigli's saw (Fig. 191). Next the dura mater is carefully detached towards the anterior end of the petrous bone. Then three difficulties are encountered, (*a*) The middle meningeal artery emerging from the foramen spinosum may run behind the area. It may be ligatured without difficulty, or the foramen or bony canal plugged by cotton-wool, wax or a match; however, the external carotid has had to be tied; (*b*) The cavernous sinus and branches may cause venous hæmorrhage, which may be checked by sponge pressure for a minute or so, but it may be so free that the wound has to be plugged and the operation interrupted, to be resumed after some days; (*c*) The removal of the ganglion is accomplished by dividing the second and third divisions at the foramina, avoiding if possible the motor root, by drawing and twisting out the ganglion from its bed. The ophthalmic

division is left if possible, not only from the danger to the eye, but also to avoid tearing into the cavernous sinus in trying to get at the nerve in the sphenoidal fissure. When it must be included, the dura may be divided a little behind the ganglion, so that the whole root can be got at; this of course destroys also the motor division.

The eye is endangered whenever the first division is involved, as the cornea is rendered insensitive, and it is easy for irritation to go on to destruction of vision. Before the operation the eyelids should be closed either by strapping or temporary suture; no strong antiseptic should be allowed to come in contact with the eyeball, nor any rough manipulation to bruise it. After the operation the eye should be protected by a watch-glass or celluloid plate fixed by strapping.

The anæsthesia is not important after the removal of single branches of the fifth nerve as the areas overlap so much; removal of the Gasserian ganglion, however, produces permanent anæsthesia, and it may be paralysis and wasting of the lower-jaw muscles from removal of the motor root. A hollow forms in the temporal region, and the movements of the jaw may be impaired. Relief of pain follows temporarily, but a return occurs in some cases even when there has been a free removal, from the disease progressing on the proximal side of the ganglion. Death has occurred from shock to a previously exhausted patient submitted to a prolonged operation; from free hæmorrhage, also from septic changes, such as meningitis, or superficial abscess, infection coming possibly through an exposed nasal sinus or the Eustachian tube.

Facial spasm.—Facial spasm may occur without pain, or be associated with neuralgia of the fifth nerve. Medical remedies failing, the nerve has been stretched outside the stylo-mastoid foramen. If this is done, paralysis of some months' duration follows, and meanwhile the spasms are absent, but in only two cases out of twenty was the relief permanent, in the others it recurred. The nerve should certainly not be resected or torn out, at any rate at the first operation, on account of the inevitable paralysis and deformity resulting. *Stretching the facial nerve.*—An incision is made from the base of the mastoid process to the angle of the jaw, the lobule of the ear hooked upwards, the parotid gland forwards, and the posterior auricular artery backwards. The anterior border of the mastoid process and the edge of the sterno-mastoid are exposed behind, also the posterior belly of the digastricus passing forwards and just over the external carotid. Above the attachment of the digastricus the nerve appears at the anterior border of the mastoid process, and stretches forwards to reach the vertical ramus of the jaw about midway between the joint and the angle. A restoration in part of the functions of a paralysed facial nerve has been accomplished by grafting into it the spinal accessory or hypoglossal.

Spinal accessory nerve.—Spasmodic wryneck, tonic or clonic

spasm, has often no apparent cause, although reflex irritation from the teeth, scalp, enlarged glands, a scar of a wound or a foreign body are occasionally the origin, and require removal. Medical means failing, division of the muscle is useless. The division of the nerve is not attended by any serious drawbacks, from paralysis, or contracture of the sterno-mastoid or trapezius, the muscles having additional supply from cervical nerves. The nerve is exposed by an incision along the anterior border of the sterno-mastoid; after division of the fascia, retraction of the muscle and hooking up the nerve, the nerve is avulsed. Stretching is suitable only for slight and recent cases, owing to the likelihood of return on recovery. It is best to steadily draw upon the nerve until it comes out by its spinal roots. Spinal hæmorrhage has not followed either in man or in experiments on animals (Claude Bernard).

Cervico-occipital neuralgia.—The neuralgia affects the upper four cervical posterior nerve branches, which are painful where they become superficial, the great occipital nerve midway between the occipital protuberance and the mastoid process, the sub-occipital nearer the middle line, other branches between the sterno-mastoid and trapezius. The nerves have been exposed, followed backwards to the spinal foramina and drawn out.

Brachial plexus.—Following injury, and for ascending neuritis, the plexus has been exposed by the same incision as for ligature of the third part of the subclavian and then stretched.

The cervical sympathetic nerve.—Its irritation and paralysis have been referred to under *Injury*, and similar results may be caused by tumour. The cervical sympathetic nerve trunk has been divided or a piece excised for the relief of glaucoma, exophthalmic goitre and epilepsy, especially for glaucoma. The operation is done by exposing the nerve, through an incision along the anterior border of the sterno-mastoid, then retracting the muscle outwards, and the internal jugular vein and common carotid artery inwards, avoiding the vagus nerve. The effect is congestion of the face and ear, with a flow of tears and mucus from the nose, and weight in the head. In some cases there has been diminished intra-ocular tension, relief from orbital neuralgia, and improvement in vision, but only temporarily. A relapse has followed.

Intercostal neuralgia — Pleurodynia. — A persistent pain has necessitated the excision of one or more intercostal nerves.

Sciatica—*Sciatic neuritis.*—Neuritis in the course of the sciatic nerve may result from cold, injury, foreign body, and fracture of the acetabulum or great sciatic notch. It may be connected with osteo-arthritis in the hip, with pelvic inflammation, a sigmoid flexure overloaded with fæces, cancer of the rectum, the pressure of the child's head or of forceps during labour, pelvic exostoses, gluteal aneurysm or abscess, or it may be due to a spinal lesion, either tuberculous or syphilitic, or to a new growth. Gout or rheumatism

are supposed to be the source of other cases, where there is no sign of a local lesion. The patient feels great pain, and has tenderness in the course of the sciatic nerve, which may become at times agonising, and be followed, if prolonged, by wasting and contracture in the calf and peronei muscles. In sciatica, the hip-joint can be flexed and moved whilst the knee is bent, but an attempt to flex the hip when the knee is extended is apt to cause excessive pain. The same movement of the sound leg may likewise cause pain in the diseased nerve by tension transmitted from the sound nerve through the cauda equina (*crossed sciatica*).

Treatment.—Rest, including even a long splint and extension, free purgation in particular with castor oil, blistering or even cauterising the skin over the course of the nerve down the thigh, have each had its advocates as succeeding in some cases. If there is great local tenderness, the nerve should be explored in the hope of finding some obscure cause, a bone spiculum, a needle, etc. Stretching the nerve is not in any way a dangerous operation, pain may be relieved for a time; unfortunately it often returns as soon as sensation is regained. However, it is impracticable to divide the nerve on account of its important functions and the paralysis and contracture of the limb which would result. The sciatic nerve may be partly stretched without a wound by flexing the hip to a right angle or more whilst keeping the knee fully extended. The incision to stretch the nerve is made along the middle of the back of the thigh in the line of the nerve, beginning just below the gluteus maximus. The biceps and semi-tendinosis are separated, and the nerve steadily pulled on, not jerked, until it lies slack in the wound. It is possible steadily to lift the body by the sciatic nerve without rupturing it. No improvement will follow if the pelvic plexus is the seat of the neuritis.

Crural neuralgia.—The anterior crural nerve may be affected instead of the sciatic. It is exposed by an incision just external to the femoral artery, below Poupart's ligament.

Perforating ulcer of the foot.—Though the pressure of a corn can generally be traced as the exciting cause of the ulcer, it would appear in many cases to depend upon changes in the peripheral nerves, leading to trophic changes in the part and a consequently lowered resisting power of the tissues to injury or pressure. It is sometimes associated with locomotor ataxia, at times with diabetes, leprosy, and spina bifida. The usual situation of the ulcer is the ball of the great or little toe. The ulcer is attended with but slight inflammation, and probing causes hardly any pain. It may lead to destruction of the metatarso-phalangeal joint, necrosis of the bones, and perhaps complete perforation of the foot; it is sometimes the starting point of gangrene. There is usually local sweating, lowering of temperature, and impairment of sensation of the foot and lower third of the leg. The patella-reflex may be lost. *Treatment.*—Though

the ulcer will often yield to prolonged rest, the removal of dead bone, scraping, taking off pressure by cutting a hole in a thick cork sole, excision of the ulcer, and even amputation is sometimes called for. Nerve stretching has also been recommended. Relapses are common.

Tumours of nerves, whatever their structure, were formerly called neuromata. This term, however, should be restricted to that rare form of tumour composed of nerve elements; whilst other tumours of nerves should be called fibromata, sarcomata, etc., as in other situations, according as they consist of fibrous tissue, sarcoma elements, etc. *The true neuromata* are exceedingly rare, and call for no futher mention.

The fibromata, though, like other tumours of nerves, far from common, are the variety most frequently met with. They grow from the connective tissue either of the sheath or of its prolongations within the nerve; in the latter case the nerve fibres will be spread out over them (Fig. 176). They are generally single, or there may be several on the same or on different nerves. *Signs.*—They occur as painful, more or less globular tumours in the course of a nerve, and are often accompanied by numbness, tingling, and perhaps muscular spasm, or wasting of skin and muscles, in the part the nerve supplies. They can be swayed from side to side, but cannot be moved up and down in the long axis of the nerve. Another form of fibrous tumour connected with nerves is the so-called painful subcutaneous tumour of Paget, which occurs as a small nodule beneath the skin, and causes the most exquisite pain when handled. The *treatment* consists in dissecting the tumour out, or if this is impracticable, removing it along with the affected portion of the nerve, and then suturing the divided nerve-ends. If the divided ends cannot be brought into contact they may be stretched, or a piece of nerve grafted in between them. The painful subcutaneous tumour is readily removed by dissection.

Fig. 176.—A median nerve with a tumour over which the filaments are spread out. (St. Bartholomew's Hospital Museum.)

The myxomata are degenerating forms of the fibroma, and give rise to similar symptoms.

The sarcomata, though more rare, may also be met with in nerves, along which they rapidly spread, as well as to the surrounding tissues. They are sometimes multiple, always malignant, so that amputation may be required.

For *neuroma plexiforme*, see p. 127.

DISEASES OF THE SKIN, HAIR, AND NAILS.

Furunculus, or boil.—A boil is a circumscribed inflammation of the skin and subcutaneous tissue, terminating in gangrene of the central part, which is then cast off in the form of a slough, popularly called the core. Boils generally occur in crops, one coming out after the other has healed; or several small boils form around a larger central one. They are usually situated on the neck, nates, dorsum of the hand, and back. Though most common in the young, they may occur at all ages. The so-called predisposing *causes* are numerous. Among these may be mentioned change of habit, a too exclusive meat diet, diabetes, albuminuria, alterations in the blood depending on acute disease, the emanations of sewer gas, changes of season or air, and cachectic conditions however induced. Any local irritation, such as chafing of the neck by the collar, or of the nates in rowing, the irritation of morbid fluids in making post-mortem examinations, may lead to the introduction of infection by the *Staphylococcus pyogenes aureus*, which is always present in boils, and is the essential cause. Chronic or recurring furunculosis is a general infection by the staphylococcus pyogenes. *Signs.*—A boil begins as a red pimple usually with a hair in the centre, and as it increases in size forms a painful, dusky, purplish-red and conical swelling, with a flattened apex. The inflammation may at times subside, and the boil gradually disappear (*blind boil*). More often the cuticle separates at the apex, a pustule forms, bursts, and leaves a yellow slough exposed, which is cast off as a central core through a single opening. Boils appear in the bearded portion of the face (*sycosis*), in the armpit, on the eyelids (*styes*), at the nape of the neck, on the buttocks. *Treatment.*—A boil may sometimes be aborted by plucking out the central hair, injecting with undiluted carbolic acid, applying nitrate of silver, or painting it over with a thick layer of collodion. Should these remedies fail, a boric acid fomentation, and, where there is much pain, glycerine and belladonna may be applied, and after the boil has broken, a simple healing ointment. A puncture under gas may be necessary. The constitutional treatment consists in attention to hygiene, regulation of the diet and secretions, administration of tonics, etc. Arsenic, yeast (3j.) and sulphide of calcium (gr. $\frac{1}{6}$ to $\frac{1}{3}$) have at times been found useful. Wright has used with success an antitoxin obtained from staphylococcus cultures.

Carbuncle is a spreading inflammation of the subcutaneous tissue involving, to some extent, the overlying skin and terminating in gangrene of the affected tissue, which is discharged in the form of sloughs. It differs from a boil in that it is of larger size, has a tendency to spread, and is flattened instead of conical; there is greater brawniness of the surrounding tissues; the skin gives way at several places instead of at the apex; the gangrenous tissue is discharged in the form of sloughs instead of as a core;

and it is accompanied by severe constitutional symptoms. *Cause.*—Any vitiated state of the constitution, such as may be induced by too high or too poor living, gout, diabetes, albuminuria, typhus or other acute fevers, prolonged lactation, and the like. Friction and pressure are mentioned as exciting causes, and are said to explain the frequency of its occurrence on the nape of the neck, back, and nates. The presence of the pyogenic micrococci is the essential cause; thus a carbuncle has been produced on the forearm by rubbing in a staphylococcus culture. Carbuncle is more common in men than in women, and does not usually occur till after the middle period of life. It is especially seen at the nape of the neck, or on the back as low as the sacrum, and is dangerous when associated with diabetes, and when it occurs on the face or scalp. In the former situation, suppurative phlebitis of the angular vein, with extension of the infective thrombi through the ophthalmic vein to the cavernous and other blood sinuses in the skull, and consequent meningitis or general blood-poisoning, is the danger to be apprehended. *Symptoms.*—It begins as a hard painful swelling, accompanied by fever, generally of a low type and with marked depression. The swelling rapidly spreads, and forms a flattened, generally more or less circular, elevation of the skin, surrounded by considerable brawny induration and redness. At first red, it soon becomes purplish-red, dusky or livid. Vesicles form over its surface, and on bursting, leave a number of apertures in the skin through which a greyish-yellow slough is seen. The apertures then coalesce, and the slough is gradually thrown off, leaving a granulating wound; or the inflammation continues to spread, and the patient may sink into a low typhoid or delirious state, and die of asthenia or of blood-poisoning, septicæmia, or pyæmia. *Treatment.*—The strength must be supported by fluid nourishment, and stimulants as indicated by the pulse and temperature. In slight cases the patient should have abundance of fresh air, and should not, if it can be avoided, keep his bed. Opium should be given where there is much pain, or be added to the fomentations. Locally, a crucial incision was formerly a favourite practice, but it is much better to make incisions through the skin down to the sloughing tissues, or to join any openings that may have already formed. All the dead tissues should be cut away, or scraped away with a Volkmann's spoon, without encroaching upon the vascular tissues around, then the surface should be swabbed with pure carbolic acid, and boric-acid fomentations applied. The lost skin can subsequently be replaced by epidermal grafts when the granulations have become healthy. Some recommend the injection of carbolic acid, 1 in 20, into the carbuncle, as a method of arresting its progress while still small.

Anthrax, see p. 109.

Superficial Gangrene, see p. 42.

Chilblains are local congestions of the skin caused by exposure

to cold and damp in young persons with a feeble circulation. They commonly occur on the fingers and toes; less frequently on the nose and ears. They present a sharply-defined, bluish-red blush of erythema, disappearing on pressure, and slowly returning. In severe cases the skin becomes dusky and purplish in colour, and the cuticle gives way, leaving a raw surface (*broken chilblains*). They are attended with intolerable itching. *Treatment.*—The general circulation should be promoted by exercise, tonics, and good food, and the local by stimulating liniments such as iodine, the parts being kept dry and warm by woollen gloves or socks worn by night and by day. When the chilblain is broken, it may be dressed with oxide of zinc or boric-acid ointment.

Onychia, or onychia maligna, as in severe cases it is sometimes called, is a chronic unhealthy inflammation of the matrix of the nail, attended with ulceration and a fœtid purulent discharge. It is most frequently met with in children as the result of a crush of the finger or some slight injury; but it may depend on syphilis or tubercle, or more rarely on eczema or psoriasis of the matrix, or its inoculation with the parasite of ringworm. In a typical case the end of the affected finger is swollen and inflamed, and of a dusky or livid red colour, whilst the nail is blackened, shrunken, loosened from its matrix, surrounded by a crescent of unhealthy ulceration, and bathed in a very fœtid discharge. It is exquisitely tender to the touch. In severe cases the ulceration may extend to the bone and neighbouring joint, and the last phalanx be lost. *Treatment.*—The nail, if black and shrivelled, should be removed by forceps, the wound powdered with nitrate of lead, or dressed frequently with a lotion of nitrate of silver. In tuberculous subjects appropriate constitutional remedies must be given. If there is a suspicion of constitutional syphilis, the part should be dusted with calomel, or dressed with blackwash, and mercury or iodide of potassium given internally. In some inveterate cases it may be necessary to scrape or shave away the matrix of the nail under an anæsthetic.

Verrucæ, or warts, are small excrescences on the skin formed by the hypertrophy of the papillæ and epidermis. The following varieties are described:—1. *Verrucæ vulgares*, or common warts, so frequent on the hands of children and young adults. 2. *Verrucæ seniles*, which occur as brownish elevations generally about the back, neck, and arms of old people. 3. *Verrucæ necrogenicæ*, common on the hands of dissecting-room porters and morbid anatomists, and often tuberculous. 4. *Venereal warts*, met with on the genitals as the result of the irritation of gonorrhœa or other irritant discharges. 5. *Soot warts*, which affect the scrotum of chimney-sweeps, and are frequently the starting point of "sweep's cancer." 6. *Congenital soft warts*, which take more the form of irregularly-shaped growths than of true warts, are

frequently pigmented and hairy (*nævi verrucosi*), and at times occupy large portions of the surface corresponding to the distribution of certain cutaneous nerves (*papillomata neurotica*. See *Lymphangioma hypertrophicum*). *Treatment.* — *Common warts* often disappear spontaneously. They may be readily destroyed by such caustics as salicylic, acetic, and nitric acid, or nitrate of silver. *Venereal warts* may be snipped off with the knife or scissors. *Senile warts*, when large, had better be excised. The *soot wart* ought also to be removed at once by the knife. The acid nitrate of mercury is highly spoken of as an application to *verrucæ necrogenicæ*. The congenital *pigmented* and *hairy wart* should be excised, otherwise in later years a malignant growth may arise. If the wart is very extensive, skin-grafting may be employed after its removal.

Clavus.—Corns consist of localised thickenings of the epidermis over enlarged papillæ, and although they may occur on any part of the body that has been subjected to intermittent pressure, are most common on the feet, where they are produced by tight or badly-fitting boots, especially when high heels have been worn, and the weight of the body has thus been unnaturally thrown upon the toes; they are for the same reason frequently met with in talipes equinus. Two varieties are described, the *hard*, occurring on exposed parts, particularly the dorsum of the toes, and the *soft*, situated between the toes, where in addition to pressure the parts are subjected to moisture. A hard corn, on section, is seen to be more or less conical; and it is the pressure of the apex of this cone upon the papillary layer of the corium that causes the pain. At times a bursa is developed beneath the corn. At other times suppuration occurs, and the pus being prevented from escaping by the hardened cuticle, gives rise to great tension, pain, and consequent inflammation of the skin and subcutaneous tissue around, and may even terminate in ulceration, which may extend deeply into the foot. *Treatment.*—A hard corn should be pared down, and then painted night and morning with salicylic acid and collodion. In the meantime all pressure should be removed by means of a corn pad, or a hollow moulded in the leather of the boot. Soft corns should be allowed to become dry and hard by separating the toes with cotton-wool, and dusting them with oxide of zinc or other form of astringent and antiseptic powder, and then treated in the same manner as hard corns. Should suppuration occur beneath a corn, an incision through it to evacuate the pus will give immediate relief, or the corn may be pared down with a sharp scalpel till the pus is reached without giving any pain. In persistent instances they are better excised. In the old, in whom senile changes have occurred in the vessels, gangrene may result from paring a corn too closely.

Horns (*cornua cutanea*) consist of hypertrophied papillæ covered by hardened epithelium. They may spring from the interior of a sebaceous cyst or from a wart, and are apt to degenerate into

epithelioma at their base. They are most common on the face and scalp. Free removal is the treatment.

Nævi and hairy moles, see p. 433.

Redundant hairs.—It is especially when they tend to disfigure the lips and chin in women that treatment is called for. Hair on the upper lip and cheeks may be seen in young women, or appear on the chin in consequence of disease or removal of the ovaries, or follow the climacteric. Among other means used to get rid of them are: Shaving and rubbing down with pumice-stone, bleaching them with peroxide of hydrogen, breaking them off by painting on collodion and pulling off the scab. The *x* rays have been used, but the hairs simply break off, and troublesome irritation or scarring has been set up. The only satisfactory method to prevent a regrowth is to destroy the hair-follicle and bulb by electrolysis. A fine needle fixed in an electrode is connected with the negative pole and inserted into the follicle beside the hair, whilst the patient grasps firmly a sponge, wet with salt and water, connected with the positive electrode. The current is turned on slowly until bubbles begin to rise beside the hair, and in less than half a minute the hair can be drawn out, bulb and all, and no scarring follows.

Atheromatous or sebaceous cysts (*wens*) (Fig. 57) occur mostly on the face, but may be met with on any part of the body, and are often multiple. They are retention cysts, do not contain hair-follicles, papillæ, or other skin elements, thereby differing from the dermoid cysts, which they otherwise resemble. The cysts on the scalp, formerly described as sebaceous, are now known to be dermoids. *Signs.*—They form smooth lens-shaped, semi-fluctuating, moveable swellings situated in the skin. They may be distinguished from a fatty tumour by not slipping from under the finger on pressing the edge of the swelling, and from an abscess by the absence of signs of inflammation. A small black punctum, the obstructed orifice of the sebaceous follicle, may generally be discovered on the surface. *Secondary changes.*—1. The contents of the cyst may undergo decomposition and become extremely offensive. 2. The cyst wall may become inflamed and suppurate, and the cyst be thus cured, or a portion of the wall may be left behind and a sinus ensue, or the wound may heal and the cyst refill. 3. One part may give way, and the sebaceous matter exude, become hardened, and be pushed up from below, and take the form of a horny growth. 4. Granulations may spring up from the interior of the cyst, and exude as a fungating mass resembling an epithelioma. 5. They may degenerate into an epithelioma. 6. Their walls may undergo calcification. *Treatment.*—They may be removed by—(*a*) Dissection. (*b*) Splitting them, squeezing out the sebaceous matter, and seizing the cyst wall with forceps and pulling it out. Care should be taken not to leave any of the wall behind, or a troublesome sinus will remain. Objection is taken by some surgeons to this method of removal in that the

wound may become infected, but practically such rarely happens. (*c*) Dilating the orifice with a probe, and squeezing out the contents. They are apt, however, to refill when emptied in this way, unless the cyst wall is also squeezed out or sufficient inflammation is set up to destroy it.

Molluscum contagiosum is the term applied to a soft tumour of the epidermis, which is contagious in that it is inoculable, it being so passed from one child to another, or from a child to its mother or nurse. The tumours are most commonly seen on the face, lips, and eyelids ; on the breast of a mother ; also on the hands, forehead, and elsewhere, being inoculated through scratches. Little

Fig. 177.—Molluscum contagiosum. Photograph of a section from a conglomerate mass on the forehead and scalp of a girl. The lobules of epithelial cells are degenerating at their centre into molluscum bodies.

swellings arise varying in size from a pin's head to a pea, hemispherical in shape, with a depression or umbilication at the apex, pearly-white or pinkish in colour. They may be single or multiple, or conglomerated into superficial lobulated masses tending to spread. They may be inoculated on other parts of the skin, or become inflamed and suppurate. On examination they are found to consist of a pearly-white pultaceous mass growing in the deeper layers of the epidermis, which proves on microscopical examination to consist of polyhedral lobules of large epithelial cells. In the centre of each mass the cells undergo changes and form the so-called "molluscum bodies." This change is one of degeneration of cells, with irregular division of nuclei, and the formation of bodies containing keratin. It is unlikely that these bodies are parasites, coccidia, as has been

affirmed, although it is very probable that the disease is due to organisms. *Treatment.*—Puncture, squeezing out of the contents, and the application of a nitrate of silver stick to the interior suffices in most cases. If not, the mass must be scraped away under an anæsthetic.

Molluscum fibrosum (see p. 122) is the term for a soft fibroma of the dermis, congenital in origin but tending to make progress after middle life. When first seen it is perhaps a soft sessile swelling covered by normal epidermis, not larger than a pea, which grows and becomes more pedunculated, until it reaches the size of a walnut or even that of an orange. Sometimes single, they are often multiple, and in extreme cases may almost cover the body. They are most common on the back. At times they are combined with pachydermatocele of the scalp, trunk, or limbs, or excessive folds of skin with or without thickening of nerves into plexuses (*plexiform neuroma*). Each polypoid swelling has a vessel running up to it, which increases in size with the tumour. A molluscum fibrosum may undergo myxomatous degeneration, or later become transformed into a sarcoma. If the tumour is irritated or become dependent, sloughing of the skin follows, and this may end in an epithelioma. *Treatment.*—Excision; when very numerous and fresh ones are appearing the rapidly-growing ones and those threatening to ulcerate should at any rate be taken away. The same treatment applies to pachydermatocele. In progressing cases, unless removal is successful, the development of multiple sarcoma may be anticipated.

Lupus vulgaris is a disease of childhood, and seldom begins after the age of puberty. It is characterised by the formation of yellowish-red nodules in the skin or mucous membrane, and subsequently by scarring and often great destruction of the affected tissues and much deformity. *Cause.*—It has been shown to be a local tuberculosis depending on the presence of the tubercle bacillus. *Pathology.*—The deeper layers of the corium become infiltrated with small round cells, amongst which new capillaries are formed. In this granulation tissue are found non-vascular areas (*tubercles*), and in them giant-cells and the tubercle bacillus have been discovered in scanty numbers. Frequently only a gelatinous breaking-down connective tissue can be made out, but the disease on inoculation sets up a slowly-developing tuberculous disease in the guinea-pig, and the injection of Koch's tuberculin causes congestion of a lupous patch. The small-celled infiltration extends along the vessels, to sweat-glands, sebaceous glands and hair-follicles, and may finally involve the whole of the corium. The granulation tissue may then either undergo degeneration and be partially absorbed without ulceration, being replaced by fibrous tissue, leaving a permanent scar; or it may undergo caseation, and the cuticle giving way, break down into an ulcer.

Signs.—The disease begins as reddish or amber-coloured, semi-transparent, apple-jelly-like nodules, the colour of which does not completely disappear on pressure. The nodules later become slightly elevated, and several coalesce, forming larger nodules or tubercles, over which the cuticle forms slight scales. The centre of the patch may now undergo atrophy and partial absorption, leaving a slightly-depressed whitish cicatrix. In this way the disease may become cured; or while cicatrisation is taking place in the centre the disease may continue to spread at the margins. Or the lupous patch may break down and ulcerate, the surrounding skin often becoming inflamed. The edges of the ulcer are raised, whilst its base is smooth, red, and spongy-looking. The ulceration may proceed gradually or rapidly, and extend through the skin or mucous membrane to the underlying structures, destroying, as when the nose is attacked, skin, mucous membrane, muscle, cartilage, and bone. The favourite seat of lupus vulgaris is the face, especially the ala of the nose; but it may attack the skin and mucous membrane of almost any part. It is more common in females than in males. From tubercular syphilis, the affection for which it is perhaps most likely to be mistaken, it may be distinguished by the age at which it began, the history of the case, and the absence of concomitant signs of syphilis.

Prognosis.—In many patients an increasing resistance offers itself, and after producing much deformity the disease is finally arrested. Less often tuberculous disease appears in glands or bones, such as those of the skull, and death may in some cases occur from meningitis or phthisis.

Treatment.—The lupous patch should be thoroughly scraped with a Volkmann's spoon, the scraping being continued as long as any soft material comes away, and until the tissues feel hard and resisting to the spoon. The actual cautery, or some form of caustic as nitrate of silver, should then be rubbed over the raw surface. The wound should be dressed with iodoform gauze; healing is quickly accomplished with comparatively little scarring. Any small tubercles around the main patch may also be scraped or touched with the galvano-cautery point. The most reliable treatment, however, where the disease is so situated as to admit of complete removal without producing deformity, is to cut away the whole extent and thickness of the skin and cover the raw surface with skin-grafts. Internally, cod-liver oil, arsenic, or the phosphate or the iodide of iron, may generally be given with advantage. But more important still is a prolonged course of seaside or country air. Many other remedies have been tried. At present exposure to the *x* rays, to sunlight, or the electric arc light is being employed with marked immediate success as regards healing, but recurrences are not prevented.

Lupus erythematosus is a cellular new growth characterised

by one or more circumscribed reddish patches covered by greyish or yellowish greasy adherent scales. *Pathology.*—The capillaries of the sebaceous follicles become dilated, and the tissues infiltrated with small round cells. The follicles then become enlarged and distended with sebaceous material, which exudes and forms greasy scales on the surface of the lupous patch. These scales, on removal, are found continuous with the plugs of sebaceous material filling the follicles. Later, the follicles are destroyed, and the infiltrated cells converted into cicatricial fibrous tissue. The *cause* is unknown, but it is believed to be tuberculous, because the lupous patch reacts to tuberculin injections. It has not been proved to be either hereditary or contagious. *Signs.*—It begins most commonly on the cheeks or nose in the form of one or more erythema-like red patches, which fade momentarily on pressure, and are often attended with itching. The patches become covered with greasy scales continuous with the sebaceous matter in the enlarged follicles. They usually spread by their slightly-raised edges, leaving dry, pale, depressed scars in their centre, which are productive of considerable deformity, but ulceration does not occur. The disease is nearly always symmetrical, affects most commonly the cheeks and nose (*butterfly patches*), less commonly the ears, scalp, lips, backs of the hands and fingers, and after an apparent cure is liable to a relapse. It is most frequent in women, begins in young adult life, is very chronic in its course, and is often complicated by attacks of erysipelas. *Treatment.*—The general health should be attended to, and arsenic, cod-liver oil, or iron should be given if indicated. Very numerous applications for relieving the itching and promoting absorption have been recommended, such as mercurial plaster, iodine, and oleate of zinc; but the best method is linear scarification or scraping, which must be repeated from time to time for considerable periods. The light treatment is now being applied.

SECTION V.

Injuries of Regions.

INJURIES OF THE HEAD.

Injuries of the Scalp.

Contusions of the scalp are very common as the result of falls or blows on the head, and are frequently followed, especially in children, by extravasation of blood, and the consequent formation of a *hæmatoma* or blood-tumour. In new-born infants such tumours are of frequent occurrence in consequence of severe pressure on the head during birth, especially when instruments have been used, and are then known as *cephalhæmatomata*. The blood may be extravasated (1) between the aponeurosis and the pericranium (*subaponeurotic*); and (2) between the pericranium and the bone (*subpericranial*). In the latter situation the resulting tumour is generally circumscribed in consequence of the pericranium being firmly attached along the lines of the sutures; in the former it is generally diffuse, and in some instances extends over the whole of one side of the head, forming a soft fluctuating baggy swelling often hanging in a loose fold over the eyes or occiput. The diffuse form can be mistaken only for an abscess, from which, however, it may be distinguished by its sudden formation, the probable concomitant extravasation of blood into the eyelid, and the absence of signs of inflammation. The circumscribed, which gives rise to a soft fluctuating tumour with hard and often sharp margins, generally occurs over one of the parietal bones, and is sometimes very difficult to diagnose from a depressed fracture. In the case of the blood-tumour (Fig 178, A) the hard margins (due to the coagulation of the blood at the circumference—the central part remaining fluid) are raised above the level of the surrounding bone, as may be detected by passing the finger along the scalp; while on pressing upon them with the finger-nail the blood may be displaced and the bone be felt beneath. As a rule, the blood becomes absorbed, occasionally it suppurates; ossification at times occurs in the angle where the pericranium is raised from the bone. In children the

FIG. 178. — A. Section of a cephalhæmatoma; and B. a depressed fracture. The dark shading in A represents the coagulated blood.

hæmatoma sometimes appears to start atrophy of the skull which results in a gap. *Treatment.*—Under the use of evaporating lotions or ice-bag the more superficial hæmatomata usually subside. It may sometimes be necessary, however, to aspirate those more deeply situated. If suppuration occurs a free incision should be made. It is not wise to apply pressure lest the scalp slough.

Wounds of the scalp vary in extent from a mere scratch to an extensive denudation of the bone, and, like other wounds, may be incised, punctured, lacerated, or contused. A contused wound often appears only incised owing to the tenseness of the scalp. Though large portions of the scalp may be torn up from the bone, sloughing is very rare, as the arteries which supply the scalp run between the skin and the aponeurosis, and hence are contained in the flap. Scalp-wounds are frequently attended with sharp hæmorrhage; they are also often associated with a fracture of the skull, search for which should always be made by passing the finger into the wound, as owing to the mobility of the scalp, the wound may not lie over the fracture of the skull. Moreover, they are apt to be complicated by erysipelas or cellulitis, with the formation of pus between the aponeurosis and the pericranium, and, where the bone has been much contused, by suppuration beneath the pericranium, in the diploë, or between the bone and dura mater. Suppuration in any of these three situations may be followed by necrosis of the bone, by septicæmia or pyæmia, or by inflammation of the brain and its membranes. When a flap of the scalp has been completely detached, and even when the pericranium has also been lost, necrosis need not necessarily occur, since granulations may spring up from the bone, and cicatrisation follow. When much of the scalp has been destroyed, *e.g.*, by an epileptic falling into the fire during a fit, or has been torn off when a woman's hair has caught in machinery, a patch of bare bone is left in the centre with the edge of the scalp fixed down.

Treatment.—The scalp should be shaved for some distance around the wound, well washed with soap and water, then with ether or turpentine, and finally with an antiseptic, whilst the wound should be carefully cleansed from all loose hairs, dirt, grit, etc., then flushed out with the antiseptic lotion, and, if small and incised, closed with adhesive strapping over a pad of sal alembroth gauze and supported by a capeline or other form of bandage. When large portions of the scalp have been stripped up but not detached, the flaps after cleansing, however much lacerated, should be carefully replaced, and secured by aseptic sutures. Hæmorrhage is as a rule readily controlled by applying a ligature or suture, so avoiding excessive application of pressure. If the wound is extensive the scalp should be completely shaved and cleansed as above mentioned, any dependent pocket being drained through a button-hole incision, whilst the patient should be kept at rest for a few days, placed on low diet, a smart purge given, and a careful watch made

for signs of suppuration. Should such occur, the adhering margins of the wound should be separated to permit the free escape of the pus, and the wound be allowed to heal by granulations. If pus forms at some distance from the wound, an incision must be made at that spot through the scalp, of course avoiding the track of any large vessel. If bone has been widely bared of its pericranium, iodoform gauze should be applied and changed daily until granulations derived from the vessels of the diploë cover the surface, when the edges of the scalp can be raised and drawn together; or if much of the scalp has been destroyed epidermal grafts may be applied.

Injuries of the Cranial Bones.

Contusions of the cranial bones are always serious, especially when attended with a wound of the scalp, inasmuch as they are liable to be followed in connection with blood-clot arising from the contusion by—(1) suppuration between the pericranium and the bone; (2) suppuration in the diploë and necrosis of the external table or even of the whole thickness of the skull, with implication of the large diploic veins, and probably septicæmia or pyæmia; (3) suppuration between the bone and dura mater, and subsequent general meningitis; (4) chronic inflammatory thickening of the cranial bones or dura mater, giving rise to constant headache, impairment of one of the special senses, epilepsy, or even insanity; and (5) cerebral abscess.

Signs.—Contusions of the skull are attended by no primary symptoms, but should septic osteomyelitis supervene there will be the usual signs of inflammation localised to the injured spot, with more or less constitutional disturbance. Thus there may be chills or severe rigors, followed by high temperature, and probably, later, signs of septicæmia or pyæmia; whilst the bone, should necrosis occur, will become dry and yellowish-brown or greenish-white in colour. Pus between the bone and dura mater will be indicated by headache, vomiting, rigors, monoplegia or hemiplegia, delirium, or stupor, followed by convulsions or coma (see *Intracranial Suppuration*); whilst locally a circumscribed œdematous swelling may form over the injured parts (*Pott's puffy tumour*), or if there be a wound it will become dry and the bone discoloured, and the scalp around swollen and œdematous.

Treatment.—When, from the account of the injury, it is probable that the bone has been contused, measures should be taken to prevent inflammation by rest, cold to the head, free purging, and, where there is a wound, by strict antiseptic precautions. Should suppuration be suspected free incision through the pericranium should at once be made, the external table chiselled away, and the suppurating diploë scraped with a sharp spoon and irrigated with an antiseptic lotion; whilst, should the signs point to the formation

of pus between the bone and dura mater, the trephine should be applied.

Traumatic cephalhydrocele is a swelling caused by the escape of cerebro-spinal fluid through an aperture in the skull, the result of a simple fracture with loss of bone and implication of the subarachnoid space or ventricles. It is rarely met with, and then nearly always in children. The bone undergoes absorption, the meninges yield, and this is followed by a protrusion of a horn of the lateral ventricle covered by a thinned-out layer of brain substance, or the protrusion may occur in connection with the third or fourth ventricle. Puncture is therefore both dangerous and useless. The swelling fluctuates, pulsates synchronously with the brain, swells up on crying, and can be partially reduced on pressure. The aperture in the skull can usually be felt. It may at times be closed by bone-grafting or covered by a celluloid or silver plate inserted beneath the skin.

Fractures of the bones of the skull may be divided into—1, Fractures of the vault; and 2, Fractures of the base.

1. **Fractures of the vault.**—*Causes.*—Generally *direct* violence, as a blow on the head with a sharp-pointed body, or fall on a sharp edge. Occasionally *indirect* violence, as a blow, say, on the front of the head, causing a fracture at the back (see *Fractures of Base*, p. 474).

Varieties.—The fracture may take the form of a simple fissure (*fissured fracture*), or of several fissures radiating in various directions (*stellate or radiated fracture*); or the skull at the seat of injury may be broken into several pieces (*comminuted fracture*), one or more of which may be pressed inwards below the surface of the rest of the bone (*depressed fracture*); or a portion of bone in rare instances, as in some forms of hatchet and sabre wounds, may be raised above the surface of the skull (*elevated fracture*). At times the fracture consists of a mere puncture of the bone, with driving inwards into the membranes or brain of the sharp fragments of the inner table (*punctured fracture*), or of a long groove by a bullet; and lastly, the fracture may be limited either to the outer or to the inner table of the skull (*partial fracture*). In some of these varieties the scalp may remain whole, when the fracture, as in other situations, is said to be *simple;* or there may be a wound of the scalp leading to the fracture, when it is said to be *compound.* In children the bone may be depressed without fracture.

State of the parts.—In *simple fissure* there is no displacement of the bone, but a mere crack extending from the part struck for a variable distance over the vault, and frequently running through the base of the skull. In the *stellate fracture* several fissures radiate over the vault from a central point, at which the bone is frequently punctured. The *comminuted fracture* is generally compound, and one or more of the fragments may be completely detached or driven

through the dura mater into the brain, which itself may protrude through the external wound. In the *depressed fracture* the depressed fragments may be loose or firmly locked together, often forming a shallow or deep rounded or oval depression—*pond, or spoon and gutter* fractures, as they are sometimes called (Fig. 179). Spoon and furrow-like depressions are seen in new-born children, when the

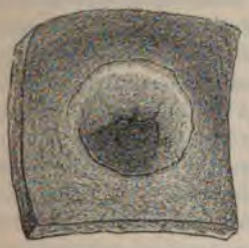


Fig. 179.—Depressed fracture (pond variety). (St. Bartholomew's Hospital Museum.)

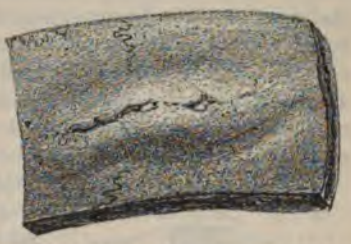


Fig. 180.—Elevated fracture, probably from the cut of a sabre. (St. Bartholomew's Hospital Museum.)

mother has a flat, rickety, or deformed pelvis, also after the use of forceps for delivery. *Gutter fractures* are produced by bullets of high velocity, attended by extensive fracture and comminution of the vitreous table. *Elevated fractures* (Fig. 180) are not often met

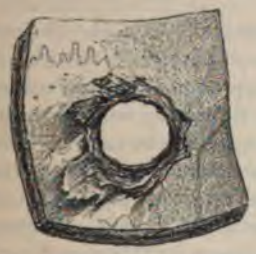


Fig. 181.—Punctured fracture. (St. Bartholomew's Hospital Museum.)

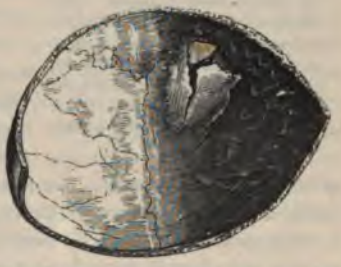


Fig. 182.—Fracture of the internal table. (Druitt's Surgery.)

with in civil practice. They are the result of oblique cuts, as by a sabre or hatchet, and only occur in young adults whilst the bone is comparatively soft. In *punctured fractures* (Fig. 181), which are generally produced by a blow with a sharp instrument, as a pick-axe or a fragment of a falling chimney-pot, or by a fall on a spike or even on a hair-comb or hat-pin, the splinters of the internal table are often driven into the dura mater or brain at right angles to the rest of the bone. Even when the membranes are not injured at the time of the accident, the irritation of these sharp fragments, if not removed,

is nearly certain to set up meningitis. At times the inflicting body has been found broken off flush with the surface of the skull. Fracture of the *external table* alone is most common over the frontal sinuses, where it is separated for some distance from the internal. In fracture of the *internal table* (Fig. 182), which is a frequent accident when a bullet grazes the skull, there may be merely a splintering of the bone, or a fragment may be completely detached or driven into the dura mater or brain. Any of these fractures may be complicated by laceration or other injury of the brain or its membranes, or by rupture of the middle meningeal artery or one of the venous sinuses. In all fractures involving both tables, except in the simple fissure, there is usually greater splintering of the internal than of the external table (Fig. 183). In fractures, however, produced from within the cranium, as by a bullet passing through the skull, the external table at the aperture of exit is more splintered than the internal. The reason for the greater splintering of the internal table (or the external table when fractured from within) is, that the force is broken in perforating the external table, and becomes more distributed over the internal. It was formerly said to be due to the internal table being more brittle than the external.

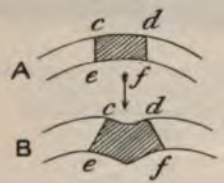


FIG. 183.—Diagram to explain the amount of splintering of the inner table. In A, *c d* marks the outer table and *e f* the inner table upon which the force causing the fracture impinges. The effect is seen in B; the points *c* and *d* approach, whilst *e* and *f* separate, the outer table is crushed together and towards the diploë, the inner table splinters inwards towards the brain.

Signs.—Whatever the form of fracture, it may be accompanied by signs of concussion, compression, or other injury of the brain. Here only are given the principal local signs of the various forms of fracture of the vault. In a *simple fissured fracture* there may be no sign, except in some cases there is pain from a nerve being caught or a crack-pot sound may he heard on percussion, but in the *compound variety* the fissure may be detected by the finger in the wound. A sharp edge of the torn pericranium, a suture, or a natural inequality may, however, be mistaken for such a fissure. A fissure may be distinguished from a suture by being straight, not serrated, and, if the pericranium be not torn, by appearing as a red, and in a few days as the blood coagulates as a black, line. In the *depressed fracture* the depression in the bone in the *simple* variety may be obscured by extravasated blood either in the scalp or under the pericranium, but in the *compound* variety it can be felt by the finger and, if the wound is large, seen. In both varieties, when the bone is much depressed, signs of local compression of the brain may be present. In the *punctured fracture* the sharp fragments may be detected, with the finger or with a probe, projecting into the interior

of the cranium, and signs of local compression may or may not be present; later, symptoms of inflammation of the brain, if the fragments are not removed, will almost certainly supervene. In both the compound depressed and punctured fracture there may be comminution or loss of bone, and portions of lacerated brain substance may at times exude through the fracture. *Fracture of the inner table* is very difficult to diagnose, but later it may be indicated by an increase of local temperature, signs of local compression, and localised pain from irritation of the dura mater. It is said that a friction sound may sometimes be heard, from the rubbing of the brain and pia mater on the sharp fragments. When a fracture is situated over the frontal sinuses there may be emphysema from escape of air into the connective tissue, or if the fracture is compound air may be forced out of the wound on blowing the nose.

The dangers of fracture of the vault may be summed up as—1. Immediate, (*a*) injury to the brain, and (*b*) septic inflammation; and 2. Remote, (*a*) continued headache, (*b*) epilepsy, (*c*) insanity, and (*d*) the development of a pulsating tumour, a cephalhydrocele or encephalocele in children.

The *treatment* of fracture of the vault will necessarily vary according to the nature of the fracture and of any cerebral complications that may be present. The general indications are to prevent sepsis and inflammation of the brain and its membranes, and to relieve any existing brain complication. Thus the patient should be placed at perfect rest in a darkened room, every source of cerebral irritation avoided, an ice-bag applied to the shaven head, or, if very severe, leeches, the bowels acted on by a calomel purge, and the diet restricted to slops. When the fracture is *compound*, it should be fully exposed by enlarging the wound in the scalp, and every care taken to render the parts aseptic, and to promote healing by the first intention. 1. In *fissured* fracture, great care should be taken to remove any dirt or hair from the fissure, widening it if necessary for this purpose by chiselling away one of its margins. When symptoms of cerebral compression are present the question of trephining will turn upon the probable nature of the cerebral lesion (see *Compression of Brain*). 2. In *depressed* fracture the treatment will differ according as the fracture is simple or compound, and according as symptoms of local compression of the brain are or are not present. In the *simple* form, unless the depression is deep and there are signs of local compression, no operative interference was formerly undertaken by most surgeons. In the *compound* form, any fragment found loose or penetrating the membranes of the brain should be removed, or if depressed, raised, provided the elevator can be readily inserted beneath it. If a fragment cannot be raised by the elevator the trephine must be applied, with the pin on the edge of sound bone, and the fragment then raised by the elevator passed beneath it through the trephine hole. When, however, the depression is but

slight, as in *pond* and *gutter* fractures of the frontal bone in children, the case, unless there are signs of local compression of the brain, would by most be left. In children, pressure has been applied to the skull transversely, causing the depression to spring back like a dint in a felt hat. A subsequent atrophy may take place leaving a gap through which the pulsations of the brain are perceived. If in slightly depressed fractures nothing is done, however, the patient should be carefully watched lest inflammation supervene, on the first signs of which the depressed bone should be removed by the aid of the trephine. In both the simple and compound varieties the depressed bone, if it is apparently causing compression of the brain, must be raised by the elevator or by means of the trephine.

Such perhaps has been the usual teaching, but there are many surgeons, and amongst them the authors, who now recommend the raising of the depressed fragments under nearly all circumstances, even when there is no external wound; as although many cases of depressed fracture undoubtedly recover, nevertheless inflammation of the brain and its membranes, or if this danger is escaped, subsequent trouble, such as long-continued headache, progressive mental inability or even epilepsy and insanity, may ensue from the irritation of the depressed bone, or from the damage done by it to the dura or brain. Moreover it is never certain that there may not be greater depression of the fragments of the inner surface of the skull than would appear to be the case from the examination of the exterior, or extensive splintering of the inner table. Since the operation of trephining when conducted antiseptically is attended with very little if any danger, it is safer to make an exploratory operation than subject the patient to the risks mentioned above. In *punctured* fracture the trephine should always be applied, as here the fragments are driven vertically inwards (see Fig. 181), and though they may not have punctured the dura, will invariably set up inflammation if not removed. In fracture of the *internal table*, too, if diagnosed, the trephine ought to be applied. This form of fracture was found in the recent war in South Africa to be frequently the result when a bullet had passed over the skull just touching or grooving it.

After any kind of fracture the patient should be carefully watched for a month or six weeks, and even though no complications are present at first, the greatest care should be exercised, and any indiscretion in diet, abuse of stimulants, or undue mental excitement, should be avoided. On the first sign of intracranial mischief such as local paralysis, epilepsy or optic neuritis, the trephine should be used.

2. **Fractures of the base of the skull** may be caused—I. by a blow or fall upon the vault. This is explained in three ways: (*a*) The fracture is produced at the spot struck, the fissure extending to the base (*Arran's theory*). (*b*) The skull, an elastic structure, is compressed in one direction and bulges in another

when violence is applied, and gives way either at the spot of compression or at the spot of bulging (*compression or bursting theory*). (*c*) Vibrations are set up in the bone at the part struck, and are transmitted round each side of the skull to the base, where they meet and produce the fracture (fracture by *contre coup*). II. It may be due to a fall upon the feet or nates, the fracture being then produced by the shock transmitted to the occipital bone through the spine. III. Rarely it has been caused by a sharp instrument, as a sword, thrust through the roof of the orbit or nose, or by a blow on the lower jaw, fracturing the glenoid cavity or forcing the condyle through it. As a rule the anterior, middle or posterior fossa is found fractured, according as the blow falls upon the anterior, middle, or posterior part of the vault of the skull. Should the force, however, be very severe, fissures may radiate from the seat of injury to two, or even to all three fossæ. Fractures through the middle fossa generally involve the petrous portion of the temporal bone on one or both sides of the skull. Thus they frequently extend through the internal and external auditory meatus and walls of the tympanum, lacerating the prolongation of dura mater contained in the internal auditory meatus, the reflexion of the arachnoid around the facial and auditory nerves, and the membrana tympani, and so allow of the escape of the cerebro-spinal fluid from the external auditory meatus. The fracture may also involve the lateral sinus or middle meningeal artery, in which case blood may be found mixed with the cerebro-spinal fluid that escapes from the ear. Fracture of the posterior fossa extends through the foramen magnum of the occipital bone, and frequently through the petrous portions of the temporal bones. Fracture of the anterior fossa involves the roof of the orbit and nose. One or more of the nerves that escape through the bony foramina in the base of the skull, the lateral sinus, the middle meningeal artery, or one of the smaller blood-channels are frequently torn or otherwise injured in a fracture of the base; whilst the inferior lobes of the brain are often extensively lacerated and contused, or compressed by extravasated blood. It should be remembered that a fracture of the base, if the membrana tympani or the mucous membrane covering the cribriform plate of the ethmoid bone is ruptured, is really a compound fracture, and further, if the prolongation of dura in the internal auditory meatus is torn the membranes are exposed; hence such fractures are liable to be followed by septic inflammation, which, moreover, may spread to the membranes and brain.

Signs.—At times there may be none, and the nature of the injury may be quite overlooked. Generally, however, symptoms, such as compression, indicative of a severe lesion of the brain co-exist, and these, together with the history of the way in which the injury occurred, should lead us to suspect that the base is

fractured. The signs, however, which when present may be considered diagnostic of the injury are—1. The escape of cerebro-spinal fluid from the ear, nose or mouth, or from a wound if one exists. 2. The escape of blood from similar situations. 3. Effusion of blood under the conjunctiva, about the mastoid process, or in the sub-occipital region. 4. Escape of brain matter from the ear and nose; and 5. Injury of one or more of the cranial nerves.

1. Cerebro-spinal fluid consists principally of water holding in solution chloride of sodium. It has a low specific gravity (1002), is slightly alkaline, and contains a substance which reduces copper oxide (pyrocatechin), and little or no albumen. When it escapes in considerable quantities (several pints in the twenty-four hours) immediately or soon after an injury, it is pathognomonic of fracture of the base. Escaping from the ear, it indicates laceration of the dura in the internal auditory meatus, and hence fracture of the middle or posterior fossa; from the nose or mouth, generally the anterior fossa, though in fracture of the middle or posterior fossa it may, by passing along the Eustachian tube, or through a fracture of the basilar process with laceration of the mucous membrane of the pharyngeal vault, also come from the nose or mouth. As a matter of present-day experience with antiseptic treatment the escape of cerebro-spinal fluid is very small as a rule.

2. Blood may escape from the same parts and by the same channels, but has not the like diagnostic value, since bleeding from the ear, and especially from the nose, may occur from causes other than fracture. Still when blood escapes in considerable quantities, and for some time after the injury, it is when combined with other evidence of severe cerebral mischief a sign of importance. It should not be forgotten that blood coming from the nose or roof of the pharynx may be swallowed and afterwards vomited or passed per anum.

3. Effusion of blood under the ocular conjunctiva and ecchymosis about the mastoid process and sub-occipital region, are signs of less value; the former may indicate fracture of the anterior, and the latter fracture of the posterior fossa, the blood passing along the floor of the orbit in the one case to the conjunctiva, and in the other draining through the fracture and appearing under the skin.

Effusion of blood *under* the conjunctiva in fracture of the anterior fossa must be distinguished from effusion of blood *into* the conjunctiva in "black-eye." In fracture the ecchymosis does not appear till after a few days, and then first under the ocular conjunctiva, usually at its outer part, in the form of a bluish-purple cone with the apex towards the cornea; it then gradually makes its way into the lower lid. In "black-eye" the ecchymosis comes on immediately after the injury, the blood at first reddish-purple in colour passing

into the upper lid and palpebral conjunctiva. It is associated usually with other evidences of bruising.

4. Injury to one or more of the cranial nerves will be indicated by paralysis, loss of function, or spasm of the parts which they supply. Thus there may be dropping of the upper eyelid (*ptosis*), external squint, loss of accommodation, double vision (*diplopia*), and dilatation of the pupil, when the third nerve is affected; spasm or paralysis of the facial muscles (*Bell's paralysis*), deafness or loss of sight if the facial, auditory or optic is injured, etc., but as the patient is frequently comatose these signs may not afford much information. The paralysis when the facial nerve is affected may come on immediately after the accident; or not for some days or weeks. In the latter case it is due either to inflammatory effusion about the nerve as it passes through the aqueduct of Fallopius or compression by callus in the healing of the fracture. The fifth nerve and its branches may be involved, causing pain or loss of sensation; also the twelfth nerve, causing paralysis of the tongue.

The *prognosis* is always grave, the lesion generally, though not invariably, terminating fatally from concomitant injury to the brain, or from septic inflammation of the brain and its membranes.

The *treatment* should be directed towards the prevention of inflammation of the brain, in the way described under *Fractures of the Vault* (p. 470). When the membrana tympani is ruptured, an attempt should be made to prevent septic inflammation, by syringing out the auditory meatus with carbolic or sublimate lotion, and applying an antiseptic dressing to the cleansed ear and shaven scalp around. To prevent infection by the Eustachian tube the nose and naso-pharynx may be well cleansed by antiseptic sprays, insufflated with iodoform or boric acid and the nose lightly packed with iodoform gauze. Should intracranial inflammation supervene, it must be treated in the way indicated under that head (p. 490).

Injuries of the Brain and its Membranes.

Concussion of the brain.—This term is applied to a collection of symptoms formerly supposed to depend on a shaking or commotion of the brain substance. It is popularly spoken of as "stunning."

Pathology.—The exact condition of the brain that gives rise to the symptoms of concussion is not known. The appearances found after death are not constant. In some cases there has been no lesion of any kind; generally, however, there are punctiform extravasations of blood in its substance. The serious lacerations and contusions that have also at times been present are more probably concomitant lesions that have little or nothing to do with the production of concussion. As the brain is constantly

found anæmic, and the right side of the heart and venous system are invariably engorged, as in death from shock, it has been thought that the symptoms may depend upon some disturbance of the circulation consequent upon paralysis of the vasomotor centres in the medulla. A theory that has lately gained ground is that known as Duret's. He holds that the skull being elastic, the violence causes a cone of depression in the cranium at the part struck, with a cone of bulging on the opposite side. In this way he assumes that the cerebro-spinal fluid is driven from the ventricles of the brain through the aqueduct of Sylvius into the fourth ventricle, whence it is unable to escape sufficiently quickly through the foramina of Magendie and of Key and Retzius, and hence causes pressure on the vasomotor centres, and induces an anæmia of the brain. The punctiform extravasations he looks upon as caused by the rupture of the capillaries suddenly deprived of the support of the cerebro-spinal fluid.

Symptoms.—Concussion may be divided into two stages—1. Insensibility; 2. Reaction. 1. *The first stage* comes on immediately on the receipt of injury; it may be quite transitory, the patient merely losing consciousness for a few minutes, and then recovering completely; or it may last for a few hours, or a few days, or even longer. The patient lies in an unconscious condition, but can perhaps be roused momentarily by shaking him, or shouting in his ear. At times he is quite insensitive to pinching or other stimuli. There is loss of all power of motion, the muscles being often relaxed and flaccid; the pulse is feeble, fluttering, often frequent; the respirations are shallow and quiet or sighing; and the surface is cold, often clammy, the temperature sometimes being as low as 97° F. or 96° F. The pupils are variable, and as a rule sensitive to light, but in very grave cases may be widely dilated and give no light reflex. The sphincters are often relaxed at the time of injury, allowing the involuntary passage of fæces and urine, but are not paralysed. This condition, after lasting for a variable time, usually passes gradually into the second stage—that of reaction; or symptoms of compression or of inflammation of the brain may come on without the patient recovering consciousness. 2. *The second stage*, or that of *reaction*, is marked by a gradual return to consciousness, and is usually preceded or accompanied by vomiting, which is therefore regarded as a favourable omen. The patient may turn on his side, draw up his legs, and pull the bedclothes over him. The skin becomes warm, the pulse increased in frequency, and the temperature slightly raised. These symptoms commonly terminate in complete convalescence, or they may run into those of inflammation of the brain. At times, however, the patient may relapse into a state of unconsciousness and die, or he may pass into the condition known as *cerebral irritation* and then recover, or certain impairments of brain function may remain.

The *remote effects* of concussion may be enumerated as headache, confusion of thought, loss of memory, mental irritability, impaired virility, optic neuritis and atrophy, epilepsy, or even insanity. These after-effects are more likely to occur if there is an inherited predisposition to nervous diseases, and appear to be brought on by excitement, abuse of stimulants, or excesses in diet. In some of these cases the brain has been examined after death, but no organic lesion has been found. Usually, however, a cicatrix in the brain, a thickening of the membranes, or a depressed fracture has been discovered.

Treatment.—The chief indication is to restore the cerebral functions by promoting the cerebral circulation, taking care not to produce too violent a reaction. Thus the patient should be placed at perfect rest; warmth applied to the surface by means of blankets, hot bottles, and, if necessary, by friction; and small quantities of diffusible stimulants, as ammonia or warm tea, administered. Alcohol should not as a rule be given; but if the patient is dying of syncope, then brandy may be given by the rectum, and ether or strychnine injected subcutaneously. When reaction has come on, inflammation must be warded off by gentle purgatives, low diet, and the avoidance of stimulants and of mental exertion.

Compression of the brain after an injury may be caused by: 1. A fragment of depressed bone; 2. Extravasated blood; 3. Pus, or other inflammatory product; 4. A foreign body, such as a bullet; and 5. Cerebral œdema. Compression of the brain may also occur from other than traumatic causes, such as tumours, abscess due to otitis media (see *Cerebral Tumour*, *Abscess*, etc.).

The *signs* of compression, *i.e.*, of pressure on the brain, vary according as the compression is made over a wide area or is localised to a particular part. Thus, when the pressure is *diffused* over a considerable portion of the brain, the patient lies in a completely unconscious state, and cannot be roused either by shouting in his ear or by shaking him. The extremities on one or both sides are paralysed; the face is livid, at times flushed; the temperature is usually low, but at times raised; the pulse is full and slow, often not beating more than forty to the minute, but it becomes quick, weak and irregular as the compression increases, and the cardio-inhibitory centres in the medulla get exhausted; the respiration is slow, laboured, and stertorous, *i.e.*, a peculiar noise is made during expiration by the flapping of the paralysed soft palate, but like the pulse it becomes rapid as the compression becomes deeper; the cheeks and lips puff out at each expiration in consequence of paralysis of the buccinator and muscles of the lips; the pupils are fixed (*i.e.*, the iris does not respond to light), and may be either dilated or contracted, or one may be dilated and the other contracted. When the pressure is diffused equally

over the brain both pupils are at first contracted, but later become dilated. When the pressure is greater on one side, the pupil of that side first passes from contraction to dilatation, and then as the pressure becomes more equally diffused the opposite pupil does the same. Hence, if caught at the right period, one pupil may be found dilated and one contracted. The urine is at first retained owing to the paralysis of the muscular coat of the bladder, but afterwards dribbles away as the bladder becomes over-distended and will hold no more; the fæces pass involuntarily in consequence of paralysis of the sphincters. At times there are violent convulsions. The compression-symptoms may gradually deepen till the patient dies; or he may recover on the removal of the cause, *e.g.*, a depressed piece of bone or a clot of blood. When the pressure is *localised* the coma is usually less profound, the pupil only on one side may be fixed and the paralysis may be limited to one side, possibly to an arm or leg, or to one side of the face, or there may be convulsive twitching of certain muscles or of a limb.

The diagnosis of the cause of the compression will rest on the fact that when due to bone or blood the symptoms come on within twenty-four hours of the injury, generally directly if due to bone, or after a brief interval of consciousness if due to blood; but not till three or four days after the injury if due to the pressure of inflammatory exudation or of pus, in which case, moreover, they are preceded by signs of inflammation. Where the signs are general, as given above, the injury usually depends upon the pressure of extravasated blood on some of the central portions of the brain following upon laceration of the brain substance, or upon spreading œdema or general inflammation of the brain or its membranes. But when the signs are those of local pressure on the surface of the brain, the lesion will probably be due to a depressed portion of bone or a circumscribed extravasation of blood between the bone and dura, or a collection of pus either between the bone and dura or in the cortical substance of the brain.

The diagnosis of the seat of compression is difficult when the patient is comatose. A scalp-wound, bruise, or depressed fracture points to the compressing agent being on the same side, but it must not be forgotten that it may be on the opposite side, the brain having been injured by *contre coup*. Twitchings, convulsions, rigidity, or paralysis of one side point to a lesion on the opposite side, a unilateral dilated pupil to an injury on the same side; a unilateral rise of temperature to an injury on the opposite side. Having thus determined which side of the brain is injured, the exact seat of the lesion may next be made out by noting what group of muscles are affected and the order in which paralysis sets in.

The conditions that may simulate compression of the brain are—

(1) Intoxication by alcohol; (2) Opium poisoning; (3) Apoplexy; (4) Uræmia; (5) Diabetic coma; (6) Heat-stroke; and (7) Post-epileptiform coma. The presence of paralysis in compression and apoplexy, its absence in opium poisoning, intoxication and uræmia; the condition of the pupils—dilated and fixed in compression, contracted unless the patient is roused in intoxication, contracted to pin points in opium poisoning; the presence of œdema of the legs and of albumen in the urine in uræmia; and of sugar in the urine and of a peculiar sweetness of the breath in diabetes; the fact that the patient has bitten his tongue and was seen to be convulsed and froth at the mouth in epilepsy; and the excessive heat of the weather in heat-stroke, are some of the points that may be of service. The diagnosis of these conditions, however, is often attended with great difficulty. Thus the head injury may be the result of a fall due to a fit of apoplexy, or the head injury or apoplexy may occur whilst the patient is drunk, or again the apoplexy and resulting head injury may be caused by uræmia. *Treatment.*—In all cases of doubt, therefore, it is better to treat the case as if a serious head lesion has occurred than to condemn a patient with apoplexy or fracture of the base of the skull to die in a police cell on the assumption that he is only drunk.

The *operative treatment* will necessarily depend upon the cause of the compression. Thus a depressed fragment of bone should be raised (see *Depressed Fracture*), a clot between the bone and dura let out by the trephine, and a circumscribed collection of pus between the bone and dura, or in the membranes or brain, also removed by the trephine. But when the depression depends upon extravasated blood in the subdural or subarachnoid space or substance of the brain, or upon a general inflammation of the brain and its membranes, no surgical procedure is, as a rule, of any avail. In any case, therefore, the first point to consider in regard to treatment is whether the compression of the brain is due to a removeable cause, or to one that is beyond the reach of surgery.

Extravasation of blood in the cranium may occur—1. Between the bone and dura; 2. In the subdural space; 3. In the subarachnoid space; and 4. In the substance of the brain.

1. *Blood between the bone and dura (subcranial extravasation)* is generally due to rupture of the middle meningeal artery, especially its anterior branch. The rupture is commonly caused by a fissured fracture extending across the line of the artery, but it may be caused by a punctured or depressed fracture or by a blow on the side of the head detaching the dura with the artery from the bone; the vessel is then torn at the spot where it emerges from its groove or canal in the temporal bone. At times subcranial hæmorrhage is due to a wound of the lateral sinus or a laceration of some of the small vessels which run between the dura and the bone. The blood is usually extravasated in large quantities, widely separating the

dura from the bone, and producing severe compression of the brain (Fig. 184). Should the patient survive, the blood may become organised or absorbed.

2. *Subdural extravasation* is usually due to rupture of capillary vessels, but may depend on rupture of the middle meningeal artery in the situation of the foramen spinosum, where the dura is so firmly attached that it is not readily stripped up from the bone. It is very common in severe head injuries. The blood usually extends widely over the surface of the arachnoid, and, if the patient survive, may become absorbed or organised, forming a false membrane, and in some cases a blood cyst.

Fig. 184.—Subcranial hæmorrhage, the result of a depressed fracture. (St. Bartholomew's Hospital Museum. No. 881 *b*.)

3. *Subarachnoid extravasation* is generally associated with contusion or laceration of the brain and may depend upon rupture of the middle cerebral or other artery. The blood may spread widely, and the patient die of compression, or it may in some cases become absorbed, but it does not as a rule become organised.

4. *Blood in the brain substance* (*intracerebral extravasation*) is the result of contusion or laceration of the brain, with rupture of the small vessels. When the laceration is extensive, it is usually fatal; but should the patient survive, the blood may undergo changes similar to those of an ordinary apoplectic clot, or may break down into pus (*cerebral abscess*).

The *symptoms* of intracranial extravasation are those of compression of the brain, but vary according to the situation of the blood and the rapidity with which it is extravasated. The diagnosis may be more or less obscured by the presence of concomitant injury to the brain. 1. When the *blood is between the bone and dura* the patient, to take a typical case, is concussed at the time of the injury, recovers from the concussion, and is, perhaps, rational for a few hours or it may be for merely a few minutes; then as the action of the heart becomes more forcible and blood is poured out from the wounded vessel, he grows faint and gradually sinks into a state of coma. The coma deepens, and he usually dies in from a few hours to a few days after the injury with signs of profound compression of the brain. The paralysis at first is on the side *opposite* to the injury, and only a limited area of the cortex may be

affected, as the face or arm centre, but it becomes general as the blood extends over the surface of the brain. Twitchings of the face or arm often precede the paralysis. The pupil on the *same side* as the injury may at first react to light, but becomes dilated and fixed as the blood extends to the base and presses on the third nerve. At times the eyeball may protrude owing to pressure upon the cavernous sinus. Very occasionally reflex convulsions, also on the side of the injury, may be set up by irritation of the nerves of the dura. A higher surface-temperature may occasionally be detected on the side *opposite* to that of the injury. If a fissured fracture is present, there may be some fulness externally from the escape of blood through the fissure. 2. When the *blood is in the subdural space*, the signs of compression usually come on rapidly, and without any lucid interval; but there are no special symptoms by which it can be diagnosed, or, indeed, at times, distinguished from blood between the bone and dura. 3. When the *blood is beneath the arachnoid* in quantities sufficient to cause compression, it will probably be associated with severe laceration of the brain, and the patient will not, as a rule, regain consciousness (see *Laceration of Brain*). 4. When the *blood is in the brain substance* it produces symptoms which cannot be distinguished from those of apoplexy, except perhaps by the history of the injury, and not always then, as it may be impossible to determine whether the patient first fell and thus injured his brain, causing the effusion of blood into its substance, or whether a vessel first gave way, and the fall was the consequence of the escape of blood into the brain. In attempting to make out the situation of the hæmorrhage, some help is said to be obtained by *puncture* of the subarachnoid space in the *lumbar* region. Thus, if the cerebro-spinal fluid drawn off is clear, the blood is probably between the bone and dura; if it is blood-stained, the blood is probably in the subdural space; whilst if it contains much blood, the extravasation is probably beneath the arachnoid and in the brain substance, and points to severe laceration of the brain.

Treatment.—When it is clear that the hæmorrhage is from the middle meningeal artery, the trephine should be applied for the purpose of removing the clot and securing the bleeding vessel. The situation of the anterior branch of the artery, the one which is nearly always torn, is about an inch and a half behind the external angular process of the orbit and the same distance above the zygoma (Fig. 185, A); over this spot a crown of bone should be removed. If clot now protrudes at the opening, it should be turned out by some form of scoop, and if the bleeding artery is then seen, an attempt should be made to tie or twist it, or secure it by a ligature passed round it with a curved needle through the dura, or it may be compressed by plugging the groove in the bone in which it lies with a piece of aseptic wax or gauze. If the bleeding point

cannot be reached, more bone should be cut away. If, however, on the removal of the clot, the brain does not expand, and the hæmorrhage is so profuse that the wounded artery cannot be seen, the external or common carotid artery may be compressed or tied, and ice applied to the side of the head. If no clot is found a second crown of bone may be removed further back in the same horizontal line, just below the parietal eminence, *i.e.*, in the course of the posterior branch of the middle meningeal (Fig. 185, B). If the blood comes from a large sinus, pressure or a lateral ligature may be applied or the whole sinus tied. When no blood is found between the bone and dura, but the dura itself is bluish in colour, does not pulsate with the brain, and bulges into the trephine hole, indicating the presence of blood beneath it, an incision should be made through it and the blood let out. The trephine wound may then be enlarged upwards and backwards, so as to expose the Sylvian fissure and middle cerebral artery, which should be tied if found wounded. Great care must be taken to keep the wound aseptic. For hæmorrhage in the substance of the brain surgical interference is not practicable; all that can be done is to treat the case as one of ordinary apoplexy from cerebral hæmorrhage, *i.e.*, by free purging, cold to the head, hot bottles to the feet, etc.

FIG. 185.—The positions for trephining to expose the A. anterior, and B. posterior branch of the middle meningeal artery. *a b*, horizontal line through meatus; *c d*, horizontal line on level with eyebrow; *e f*, vertical line 1½ inch behind external angular process; *g h*, vertical line at posterior border of mastoid process. Where these lines intersect at A and B the trephine is applied. The shading shows common situation of the clots. (Esmarch and Kowalzig.)

Spreading œdema is believed to be a not uncommon cause of compression of the brain. It has been shown by experiment that when localised pressure is made on the brain the cerebral tissue in the region of the compressing agent becomes anæmic, whilst a serous exudation occurs in the tissues around, giving rise to œdema. This œdematous area in its turn acts as a compressing agent and so leads to a further serous exudation and widening zone of œdema. Owing to the unyielding nature of the cranial bones, the œdema thus set up may extend widely through the brain and induce symptoms of general compression. It is believed that many of the forms of compression that were thought to be inflammatory are really caused by cerebral œdema. Thus is explained the sudden onset of compression that may occur in cerebral tumours, in concussion, and in laceration and contusion of the brain unattended by any evidence

of septic inflammation. Œdema is further believed to play an important part in producing the compression symptoms met with in certain forms of cerebral inflammation.

Contusion or bruising of the brain may be due to any severe violence, and may occur with or without injury of the scalp or cranial bones. It is often accompanied by laceration of the brain substance and of the pia mater and arachnoid. The bruising may be general or circumscribed. In the latter case it may occur immediately beneath that part of the cranium to which the violence was applied, or on the opposite part of the brain, the brain being as it were dashed by the violence of the blow against the cranial wall furthest from the part of the skull to which the force was applied. Like bruises of other soft tissues, it is attended by extravasation of blood from rupture of the smaller vessels. It may terminate in absorption of the blood and healing of the bruised parts, or in general inflammation of the brain and its membranes, or in local inflammation and in cerebral abscess. The *symptoms* are generally obscured by those of concussion or compression, and it is seldom that an accurate diagnosis can be made. Irritability, restlessness, and spasms of certain muscles when a motor centre is injured, are said, however, to point to contusion. The chief indication for *treatment* is to prevent the occurrence of inflammation of the brain (see p. 473).

Laceration of the brain may occur with or without fracture or other injury of the skull. The laceration, when the cranium is not perforated, is most common in the anterior part of the frontal and in the temporo-sphenoidal lobe, owing in part to the unevenness of the base of the skull on which these lobes rest, and in part to the fact that the back and the top of the head are most exposed to injury, the brain, as in contusion, being generally lacerated on the side of the head directly opposite to that on which the force is received. At times, however, the brain is lacerated directly beneath that part of the skull to which the force is applied. Laceration may also be caused by a fragment of a bone, as in depressed or punctured fracture, or by the passage of a bullet or the thrust of a sword through the orbit or nose.

Pathology.—The laceration may be slight or very extensive, and is generally accompanied by more or less bruising of the surrounding brain tissue and extravasation of blood over its surface. The pia mater is usually lacerated, and the blood may spread widely under the arachnoid. Where there is no external wound the brain tissue about the laceration becomes swollen and œdematous from serous exudation, but this, if the laceration is slight, soon subsides and cicatrisation with adhesion of the membranes ensue, the extravasated blood in the meantime undergoing the changes already described. Where there is an external wound and the laceration is produced by a fragment of depressed bone, the dura is necessarily torn, and

in some cases portions of lacerated brain may protrude through the skull. If sepsis occurs, inflammation of the brain and its membranes is set up, and either remains localised by the formation of adhesions of the membranes or becomes diffuse and spreads widely over the surface of the brain. In the localised form a hernia cerebri, or cerebral abscess, is liable to follow. If the wound remains aseptic, the changes that occur are similar to those where the skull is not penetrated.

The *symptoms* vary. At times there may be none, although a considerable mass of brain tissue is protruding through a compound fracture of the skull. Or symptoms, if present, may be obscured by signs of concussion, or, if much blood has been extravasated, by those of compression. There are no signs pathognomonic of laceration of the brain, but convulsions, localised spasms or paralysis, long continued insensibility without coma, and the collection of symptoms known as cerebral irritation, point to such an injury. The symptoms of *cerebral irritation* may be described as follows:—The patient lies in a torpid or semi-conscious condition, coiled up on one side, with his limbs in a general state of flexion. If spoken to, he evinces great irritability of temper, answering momentarily and sharply, perhaps shaking himself, and then relapses into his torpid state. His pupils are contracted, his eyes closed, but his pulse, temperature, and respirations are normal. *Method of localising the seat of the laceration where no external injury exists.*—"If a patient receive a blow upon the head, and it is found that localised paralysis is present, we conclude that there exists a laceration of some severity in the cortical centre corresponding to the muscles implicated. If almost immediately after the injury there is a distinct spasm affecting a localised group of muscles—a monospasm—we conclude that hæmorrhage is going on from the lacerated brain substance, or breaking down the tissue of the centre corresponding to the affected muscles. If the monospasm extends, first affecting one side of the body, and finally both sides, so that the attacks assume the form of true epileptic fits, it is probable the extravasated blood is extending over the surface of the brain and irritating more or less widely the whole motor area." (*Erichsen.*) Should there be motor aphasia a lesion of the posterior extremity of the third left frontal convolution (*Broca's convolution*) is indicated (Fig. 186, B). Should there be facial spasm or paralysis, a lesion of the lower third of the ascending frontal and the contiguous part of the posterior end of the second frontal convolution is probably present (Fig. 186, F^1, F^2). Should there be paralysis of the arm—a brachial monoplegia—the middle portion of the ascending frontal and the contiguous part of the ascending parietal on the other side of the fissure of Rolando are probably affected, the upper part of this area representing the shoulder, the middle the elbow, and the lower the hand centre (Fig. 186, R^1 and P^1). Should there be

paralysis of the lower limb, the lesion probably involves the upper end of the ascending parietal and the superior parietal lobule lying behind it, as far as the margin of the longitudinal fissure (Fig. 186, P^1 and P^2). Should symptoms of *cerebral irritation* be present without paralysis or convulsions, a lesion of the frontal lobe is indicated. Should there be hemianopsia, *i.e.*, loss of half-field of vision, the lesion is probably situated in the cuneate convolution of the occipital lobe; should there be loss of vision or word-blindness, a lesion of the angular convolution of the parietal lobe is likely to be present. Should there be deafness or word-deafness, the first temporo-sphenoidal convolution is probably affected.

Briefly, therefore, a cortical lesion may be distinguished from a

FIG. 186.—The cerebral convolutions: R, fissure of Rolando; F^4, ascending frontal convolution; P^1, ascending parietal convolution; F^1, F^2, F^3, superior, middle, and inferior frontal convolutions; S F, superior frontal sulcus; I F, inferior frontal sulcus; S, fissure of Sylvius; S^a, anterior limb of fissure of Sylvius; S^p, posterior limb of fissure of Sylvius; P^2, superior parietal convolution; P^3, supra-marginal convolution; P^4, angular convolution; I P, inter-parietal fissure; T S^1, T S^2, T S^3, superior, middle, and inferior temporo-sphenoidal convolutions; B, Broca's convolution; P^o, external parieto-occipital fissure; O^1, O^2, O^3, superior, middle, and inferior occipital convolutions.

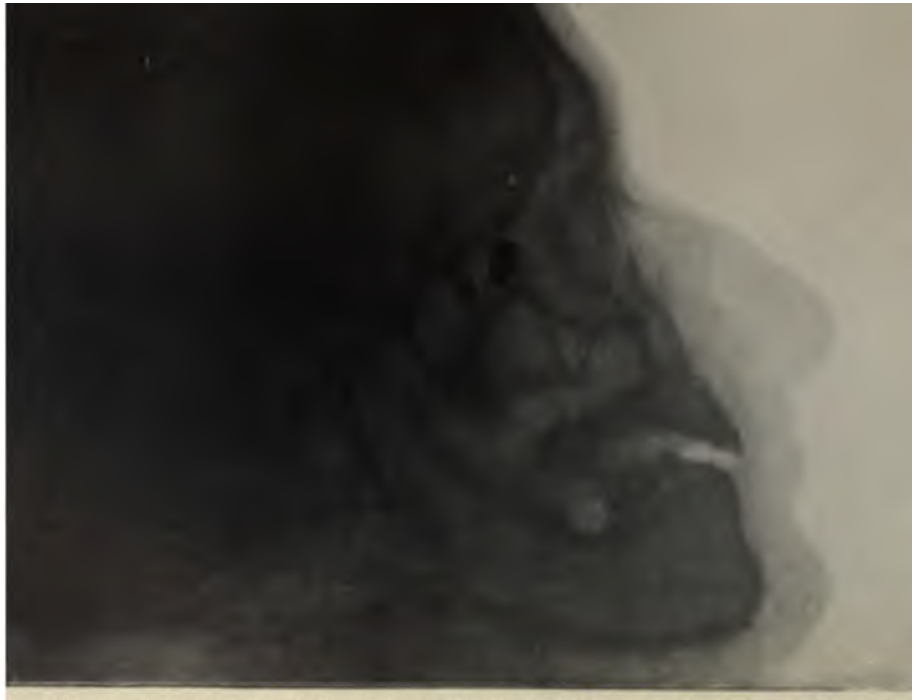
(After Lucas-Championnière and Erichsen.)

central, as follows:—In the *cortical lesion* the paralysis, although it may occur immediately after the accident, often does not appear for some hours. It is at first incomplete and localised, and probably affects only one limb or a single group of muscles, and is frequently preceded or accompanied by a monospasm of the paralysed parts, or by epileptiform convulsions of the Jacksonian variety. If the spasms or paralysis spread, they do so in a definite order. Thus, supposing the face centre to be the primary seat of the lesion, as the blood extends over the surface of the brain, the arm next and then the leg will be affected; whilst should it extend over the opposite hemisphere the order will be reversed, the leg first and then the arm, and finally the face becoming involved. In the *central lesion*, on the other hand, the paralysis occurs immediately after the injury; it is

more complete and extensive, and the whole of one side, at least, will probably be paralysed.

Bullet wounds.—A rifle bullet of high velocity may, on entering the skull, exert an almost explosive influence, and be instantly fatal. When it just grazes the skull it causes a groove of the outer table, or, even without this, splintering and depression of the inner table, or a portion of the whole thickness of skull is chipped off. In a few cases, however, the bullet has travelled through the frontal lobe without causing general destruction. Spent rifle bullets or pistol bullets may penetrate and lodge within the skull. A septic sinus may remain, from which inflammation subsequently extends, or the wound may heal, and the patient recover for a time, and then relapse, *e.g.*, with the development of an abscess in the brain. Amongst the general symptoms to which a bullet in the brain may give rise are—vertigo, irregular gait, incapacity for mental or physical exertion, deterioration of sight and hearing, or general epilepsy. An abscess may develop slowly with signs of cerebral irritation, meningeal inflammation, optic neuritis, vomiting, and compression, or may burst suddenly into a ventricle, and give rise to symptoms of apoplexy. The position of the bullet may be indicated by pain, spasms, or paralysis ; its course may be mapped out by considering the position of the patient and the direction of the bullet in relation to the topographical anatomy of the brain. An examination with the *x* rays from several positions may allow of the bullet being approximately localised (Plate VII.). The probing of the brain for a bullet is attended with danger, owing to the diffluent character of the brain, especially when inflamed. A telephone probe has been employed by which a grating sound may be heard or a bell rung when the bullet is struck, but reports as to its utility are variable. The finger has also been employed in the search, with the danger in important parts of causing laceration and resulting paralysis.

Treatment.—If there is a wound with protrusion of the brain, the scalp around is first thoroughly disinfected. Lacerated portions of brain substance are gently wiped away, fragments of bone extracted, hæmorrhage arrested, the dura mater partly stitched over the gap, and a drain inserted, after which the scalp is replaced and united except for the drain opening. When the bullet is met with close to the surface it is, of course, extracted, but no search in healthy, uninjured brain is made at the time for fear of extending septic inflammation. In the case of a retained bullet, a tube of rubber or silver is passed into the skull, or even into the cavity round the bullet, and the wound allowed to heal before the question of searching for the bullet is considered. When the wound has healed ; also, where there is no wound, but signs of local irritation or of compression of the cortical motor area from blood extravasation, the indications are to trephine. The guide to the spot for perforation is the line of the fissure of Rolando on the



Skiagram of a bullet in the skull. (Taken by Dr. Hugh Walsham at St. Bartholomew's Hospital.)

[*To face p.*

side opposite to that of the localised spasm or paralysis. This line may be found in various ways. (1) M. Lucas-Championnière (see Fig. 187) first finds the bregma, *i.e.*, the spot where the coronal joins the sagittal suture, by carrying a line directly over the vertex from one external auditory meatus to the other. The upper end of the Rolandic fissure is situated about two inches behind the bregma. The lower end of the fissure corresponds to a spot $2\frac{3}{4}$ inches behind the external angular process and about one inch above it. (2) Chiene folds a square of paper (Fig. 187) diagonally so as to bisect the right angle at A formed by two of its sides into two angles of 45°; then folds the paper again so as to bisect one of the angles of 45° into two angles of $22\frac{1}{2}°$. The sum of the angle of 45° and of one of the angles of $22\frac{1}{2}°$ gives an angle of $67\frac{1}{2}°$, B A C, which represents sufficiently nearly the angle made by the fissure of Rolando

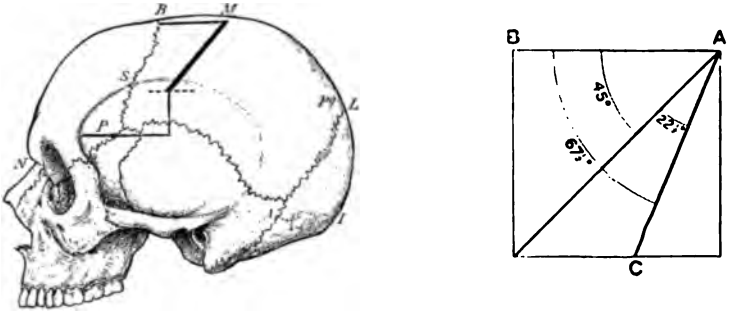


FIG. 187.—The situation of the line of Rolando. A, asterion; B, bregma; L, lambda; M, spot ½ inch behind mid-point between N, nasion, and I, inion; P, pterion; S, stephanion; P O, situation of parieto-occipital fissure.

with the sagittal suture, namely, 67°. The straight edge, A B, of the paper is then laid along the sagittal suture, the point A being applied half an inch behind a point midway between the nasion and inion, *i.e.*, to the top of the fissure of Rolando. The fissure runs for $3\frac{3}{8}$ inches along the line A C. We have already seen that the cortical motor centres are grouped around the Rolandic fissure. If therefore there is general hemiplegia, the perforation should be made over the middle of the line; if paralysis of the arm and leg, over the upper part of the line; if paralysis of the arm only, in front of the middle third of the line; if aphasia, below and a little in front of the line on the left side of the head in right-handed persons; if there is paralysis of the leg alone, behind the upper third of the line; if paralysis of the arm and face, in front of the lower third of the line; if paralysis of the arm and aphasia, or paralysis of the face and aphasia, below and in front of the line. The *fissure of Sylvius* (Fig. 186, s) may be found by drawing a line

from the pterion, *i.e.*, a spot 1½ inch behind the external angular process and 1½ inch above the zygoma (Fig. 187) upwards and backwards to a spot ¾ inch below the most prominent part of the parietal eminence. Immediately below the fissure is situated the first temporo-sphenoidal lobe (Fig. 186, T S^1). The *external parieto-occipital* fissure extends from a spot ½ inch in front of the lambda outwards for about 1 inch. The lambda (Fig. 187, L) is situated 2½ inches in front of the inion or external occipital protuberance (Fig. 187, L). Behind this fissure is the occipital lobe; in front of it the parietal lobe.

Intracranial inflammation, though at times it may remain localised either to the membranes (*meningitis*) or to the brain (*encephalitis*), more often, in whatever way it begins, spreads from the one to the other (*meningo-encephalitis*).

Cause.—Wounds of the scalp; contusions or fractures of the bone; concussion, contusions, lacerations, and penetrating wounds of the brain; middle-ear disease.

Pathology.—It may be acute or chronic, localised or diffuse. *Acute inflammation* may begin in the dura, and remain confined to that membrane or spread inwards to the other membranes and brain; or it may begin in the brain, but then seldom spreads further outwards than the pia (*leptomeningitis*). When it spreads from the bone to the dura it is at first circumscribed, the inflammatory products, and, should suppuration occur, the pus, being confined between the bone and dura. Later, the inflammation may spread to the arachnoid, and thence to the pia and surface of the brain, diffusing itself widely through the subdural space and over the cerebral cortex. When it begins in the brain it is generally the result of a contusion or laceration of the cerebral substance, and may remain circumscribed, and eventually end in a cerebral abscess, or spread to the pia and then become diffuse. It seldom, however, involves the free surface of the arachnoid. The post-mortem appearances commonly observed in the diffuse form are increased vascularity of the brain and its membranes, an exudation of greenish-yellow lymph over and between the convolutions, and distension of the ventricles with a serous blood-stained fluid; whilst the grey matter is of a reddish hue, soft and diffluent, and the white more abundantly dotted over with "puncta vasculosa" than natural. In the *chronic form*, which is generally due to inflammation, caries or necrosis of the bone, or more rarely to a brain injury, the dura becomes thickened (*pachymeningitis*) and adherent to the bone, the arachnoid thickened, and the pia opaque and indurated, so that when removed its prolongations, which dip between the convolutions, can be pulled out without tearing.

The *symptoms* vary according as the inflammation is acute or chronic, circumscribed or diffuse; according as it begins in the dura or in the brain and pia; and according as it involves the vertex or

base of the brain. The *general symptoms* in acute cases are, in the early stages, fever, pain in the head, generally on the same side as the wound if one is present, intolerance of light and sound, retching with probably a clean tongue, a quick, full pulse, flushed face, contracted pupils, violent beating of the carotids, restlessness, sleeplessness, and at times convulsions or violent delirium. Later the symptoms pass into those of compression, the pupils becoming dilated and fixed, the pulse slow and the breathing stertorous. Then follow paralysis, stupor, coma and death. Rigors will probably occur should pus form. When the cortex is chiefly affected the irritation of the motor centres may give rise to convulsions and paralysis, whilst when the base is involved, retraction of the head, rigidity of the extensors, and optic neuritis may be present. In the *chronic form* of inflammation the symptoms are similar to those of the acute, but of less severity, and are later, as a rule, in making their appearance. Complete recovery may have apparently taken place, or there may have been headache or irritability of temper previous to the symptoms setting in. *Method of localising the inflammation.*—1. If ten to twenty days have elapsed since the injury; if the onset of the symptoms is sudden, though preceded perhaps by some headache; if there is an œdematous swelling over the seat of injury (*Pott's puffy tumour*), due to the separation of the pericranium from the bone by serous effusion; if the bone, should it be exposed, looks dry, white, and discoloured, or the wound unhealthy; and if the paralysis is localised,—the inflammation is probably between the bone and dura, and if a rigor has occurred, pus has probably formed. 2. If, on the other hand, there is no apparent injury of the scalp or bone; if the patient has had concussion; and if the symptoms set in a few hours after the injury,—the inflammation is probably in the brain or pia, where it has arisen in consequence of increased vascularity following the concussion. Or if the symptoms come on about the fourth or fifth day after the injury, when it had apparently been recovered from, the inflammation will probably be also in the brain or pia, but in this case due to contusion or laceration of the brain. 3. If, again, the symptoms are delayed some weeks, if there is optic neuritis, occasional vomiting, hebetude, or symptoms of disturbance of one or more of the motor areas, the inflammation is probably localised to some portion of the brain, and if a rigor has occurred, a cerebral abscess has probably formed (see *Abscess of the Brain*), or the patient may gradually pass into a state of septic anæmia or typhoid condition.

The *treatment* may be divided into the preventive and the curative. The former consists briefly in guarding against the occurrence of septic changes in the wound if one is present, and in preventing congestion of the brain and its membranes by the means already indicated (see p. 473). The first signs of inflammation should be actively combated by a calomel purge, leeches to the temples,

and an ice-bag to the head, or Leiter's coil of tubes through which cold water can run; whilst pain should be subdued and sleep promoted by the cautious use of opium. The curative treatment consists in evacuating the products of the inflammation, should such, in spite of the preventive treatment, ensue. Thus, if there are signs of local suppuration between the bone and dura, the trephine should be applied over the seat of injury, or if one is not apparent, over the motor area at the spot indicated by localised paralysis or spasm and the pus let out. If, on removing the bone, no pus is discovered, but the dura is seen to bulge, and the pulsations of the brain cannot be felt, the dura should be perforated, and if pus is still undiscovered, but the signs of suppuration are well marked, a fair-sized trocar and cannula should be cautiously passed into the brain substance. If pus is discovered, the opening is enlarged and a drain tube inserted. If the inflammation appears to be general rather than local, no operative treatment is usually advised, but it is a question whether timely removal of some septic serum or pus by means of the trephine would not give better results than the ordinary expectant plan, although it be already widely diffused in the subarachnoid space.

Hernia cerebri is a protrusion of brain substance through a hole in the cranium and dura. *Cause.*—It is due to an increase of intracranial pressure, and may occur (1) after any injury of the cranium where there is loss of bone and a wound or sloughing of the dura, followed by septic inflammation of the underlying brain: hence it may be met with after compound depressed, and punctured fractures, or after trephining for cerebral abscess or for other brain lesion where the wound is not kept aseptic; or (2), after trephining for the relief of pressure symptoms in the case of an irremoveable cerebral tumour. *Pathology.*—The protrusion, when due to septic inflammation, consists of granulation tissue and brain substance infiltrated with inflammatory products and blood, and is the result of the inflammatory swelling of the brain causing a rise in the intracranial pressure, which thus forces the inflamed brain through the hole in the cranium. The effused blood is due to the rupture of the obstructed capillaries, consequent upon the protruding mass becoming constricted by the margins of the aperture through which it is protruding. At times, when the rupture of the capillaries is extensive, the tumour consists almost entirely of clotted blood. When the hernia follows trephining for an irremoveable cerebral tumour, and no sepsis has occurred, the hernia consists of tumour or of brain substance only, forced through the trephine hole as the tumour continues to grow and the intracranial pressure is thus increased. *Signs.*—The hernia appears as a reddish-brown, blood-stained, fungus-looking mass, overhanging the hole in the cranium, through which it has protruded, and often pulsating synchronously with the brain. Should the inflammation subside, the protrusion will

gradually recede, and the patient recover; but should it continue, the hernia will increase in size, and as more and more of the brain is involved, the patient sinks into a comatose state and dies. At times the protrusion may become constricted at its base, and slough away and the parts cicatrise; or an abscess may form in its interior and in the contiguous part of the brain, and death result from cerebral compression. When the protrusion follows trephining for an irremoveable tumour, it of course increases as the tumour grows. The *treatment* consists in attempting to allay the inflammation of the brain, which is the cause of the hernia, by the means already described in *Intracranial Inflammation*. Formerly, pressure on the protrusion, shaving it off, and applying caustics, were the means employed, but they were not attended with success whilst the hernia is inflamed. Pressure rather tends to cause an abscess or to increase inflammation and tension. The hernia itself should be dressed antiseptically, and may be painted daily with absolute alcohol. When the inflammation has become chronic, well-regulated pressure may possibly promote the absorption of inflammatory products and the shrinking and recession of the mass.

A hernia cerebri may be excised after all inflammation has subsided. The greatest antiseptic care is used, the hernia is detached and cut off flush with the brain, then a flap of scalp, pericranium, and outer table is raised by means of a chisel, and shifted across to cover the gap, whilst its place is supplied by epidermal grafting; or a silver or celluloid plate may be shaped so as to cover the hole, and the scalp united over it.

Trephining the skull.—Trephining is required in the treatment of injury, abscess, and tumour. After injury it is required in cases of (1) Compound depressed fracture, including puncture and gutter fracture by bullets, etc.; (2) in simple depressed fractures, including suspected fractures of the inner table, except in the case of the pond-shaped depressions of the frontal bone in children, and also then when any irritation or signs of subcranial hæmorrhage is present; (3) for localised intracranial hæmorrhage, especially when subcranial from the middle meningeal artery; (4) for intracranial suppuration following injury; (5) for localised cephalalgia and Jacksonian epilepsy following injury.

Trephining is also required for cerebral abscess, tumours and cysts (see *Diseases of the Brain*), and for removal of the Gasserian ganglion.

Preparation for trephining.—Whenever possible, a day or two beforehand the scalp should be entirely shaved and repeatedly washed. The lines of the sutures and bony points are noted, and the line of the fissure of Rolando and other fissures can be drawn on the scalp with an anilin pencil. When trephining is done soon after an accident time must be devoted to shaving and cleaning as detailed under wounds.

Operation.—The patient must be kept warm by blankets and hot-water bottles during the operation, and in hospital a specially heated table has been employed. The head and shoulders should generally be elevated to diminish hæmorrhage. Chloroform has been the anæsthetic usually selected, and a preliminary injection of morphine has been often given when the chloroform will be required in very small amount. But many in the case of weak patients administer ether without experiencing any excess of hæmorrhage. The most usual incision is that of turning down a semilunar flap, which is therefore left in undisturbed connection with its blood supply, and when replaced covers the gap; whereas the old crucial incision failed in these respects, the gap in the skull being under the middle of the incision. A wound should be enlarged after a semicircular fashion. If it be

Fig. 188.—Conical trephine, with improved handle.

Fig. 189.—Keen's rongeur forceps.

feared that the point under the mark on the scalp will be lost, a needle may be driven into the skull, and its projecting piece cut off. The trephine should not be applied, as a rule, over a suture, an air or a venous sinus, or over the middle meningeal artery, unless the operation is undertaken with a view to expose the sinus or secure the artery. The conical trephine, shown in Fig. 188, will be found a safer instrument than that formerly in use, as with it the dura mater is less likely to be injured. It should have a metal handle and a removeable button pin. The trephine, with the pin protruded one-tenth of an inch, should be applied, and steadily worked, clearing the teeth from time to time with an aseptic sponge or brush. When the bone is depressed the pin should be placed on the sound bone as near the depression as possible, so that the crown of the trephine is partly over the depressed fragments. A definite groove having been formed in the bone, the pin should be withdrawn. When the

diploë is reached, which may be known by the bone-dust being soft and red, greater caution must be used, and a probe introduced into the groove at intervals to ascertain whether perforation has taken place at any situation. When the crown of bone is loose it should be removed with the sequestrum forceps, and if it is intended to replace it, it should be kept warm in some sterile gauze or salt solution, and, at the end of the operation, cut into small pieces and placed in the hole, and the flap laid down over it. After the removal of the crown

Fig. 190.—Angular gouge or parting tool.

of bone, the elevator is introduced under the depressed bone, which is thus prised up into place. If more room is necessary the trephine hole may be best enlarged by rongeur forceps (Fig. 189), or by an angular gouge or parting tool (Fig. 190). Extensive pieces of bone are removed by making two or more separate trephine holes, and then cutting across the intervening bridge of bone. The Hey's saw

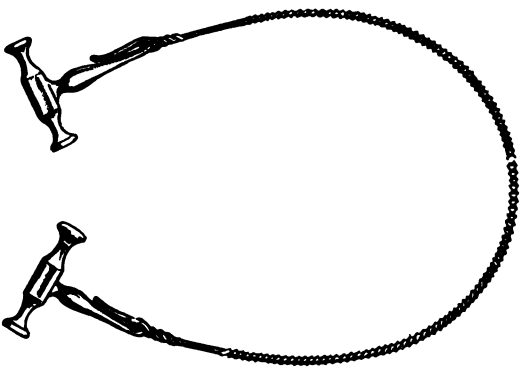


Fig. 191.—Gigli's wire saw. After removing one of the handles, the end is attached to a threaded probe, passed in at one trephine hole and out at the other, so that the saw can be drawn through, and the bone cut from within outwards.

formerly used for this is now generally supplanted by more rapidly working tools—a circular saw driven by a dental engine or electro-motor, or a wire saw passed by means of a threaded probe (Fig. 191).

Another method is by an osteoplastic flap devised so that the scalp and skull shall be raised in one flap. This is shaped like the Greek capital omega, Ω. The scalp is cut through to the bone, and then the cut is carefully deepened through the bone by a circular

dog's mouth, has united when fixed in position. To remedy the deformity so produced, also by syphilitic or tuberculous disease, the surface may be grafted with epidermis, or repaired by the Indian method of flaps taken from the forehead and side of the nose, or by the Italian method of Tagliacotius (Tagliacozzi). For slight cases refreshing the surface and epidermal grafts will suffice.

When the entire cartilage, both alæ, and the columna have disappeared, the Indian method as modified by Col. Keegan (Fig. 192) is followed. The patient being anæsthetised, and the nasal cavities on each side of the septum plugged behind with pledgets of gauze on strings, the skin over the nasal bones is turned downwards, to be employed presently in forming the external nares. To do this a lateral incision is carried downwards on each side in the line between the nose and cheek, a horizontal cut joins them across the root of the nose where a pair of spectacles rest, and a perpendicular median cut bisects the nose. Then the two flaps are turned downwards as on a hinge where the nasal skin joins the scar. Next a piece of brown paper rendered adhesive on one side is cut in the shape marked in the figure, of a size estimated to cover the defect without tension, and this is stuck obliquely on the forehead. Around this outline a sharp knife is drawn, cutting down to the periosteum, leaving a pedicle near the eyelid, and this forehead flap is now twisted round on its pedicle until it covers the raw surface exposed by turning down the nasal flaps. The nasal flaps are rolled round drainage-tubing so as to form the anterior nares with the skin surface inwards; the projection in the forehead flap forms the columna between the rolled nasal flaps, whilst the sides of the forehead flap are sutured to the cheek. The raw surface on the forehead is either drawn together by sutures or covered with epidermal grafts. The twisted pedicle of the forehead flap after a fortnight is detached completely and fashioned so as to do away with the ridge. The anterior nares being thus lined with skin do not contract, and the rubber tubes may be discarded after ten days.

The Tagliacotian method consists in covering the nose with a pedunculated flap from the arm, which is kept fixed to the head until the flap has united, and the pedicle can be cut through.

A sunken bridge, following injury or resulting from inherited syphilis, may be improved by inserting a moulded or celluloid plate beneath the skin. A fold such as that upon which spectacles rest should be chosen for the line of the incision. A marked improvement in appearance both in profile and full-face may be obtained. Recently it has been sought to accomplish this end without an incision by injecting paraffin. Paraffin melting at about 110° F. is more generally useful. If it melts at a lower temperature, *e.g.*, 104° F., it may not consolidate, but spread to the eyelids and cause chronic œdema. Paraffin melting at a high temperature, 120° to 130° F., is difficult to manipulate, requiring a water bath or heated syringe, or

needle. If inserted too hot it would cause sloughing, if too cool it sets immediately. The paraffin must be injected very gently and slowly, and pressure is kept up around so as to prevent spreading. The improvement which results, though more obvious in profile than full-face, is most satisfactory and lasting.

Salivary fistula occasionally results from a wound of Stenson's duct, or from the impaction of a calculus and subsequent ulceration through the cheek. It is known by a small fistulous opening on the cheek from which saliva dribbles, especially when food is being taken. *Treatment.*—Numerous operations have been proposed and practised for this somewhat troublesome condition. The principle underlying them all is, first to establish a free opening of the duct into the mouth, and then, if the external opening does not heal, to close it by a plastic operation. An opening into the mouth may be formed by the passage and retention of a bougie, or if the opening of the duct is not patent by the introduction of a loop of wire through the fistula across the duct into the mouth. The wire is twisted up inside the cheek, and gradually cuts its way through the mucous membrane, leaving a free passage for the saliva into the mouth.

A more rapid method is to pass a probe-pointed director along the duct and, so guided, to lay the duct open into the mouth well beyond the point where the fistula opens on to the cheek. The fistula can be forthwith pared and sutured, and will heal if the mouth be kept clean.

Injuries to the auricle.—The auricle may be *lacerated*, even completely torn off, but readily unites on being sutured in position. *Contusion* of the auricle is common in boxers and football players, giving rise to subcutaneous hæmatomas. Hæmatomas of the auricle likewise occur in the insane from even very slight injuries (see *Diseases of the Ear*).

Punctured wound of the brain through the orbit.—This is an accident the gravity of which is very apt to be overlooked until septic inflammation of the brain has set in, when it is too late to save the patient's life. A punctured wound of the upper eyelid may so close together again that it appears very small, and owing to the mobility of the skin may at first sight appear not to have penetrated the orbit. Only a limited extravasation of blood may be seen beneath the conjunctiva, yet the roof of the orbit has been perforated, and septic material carried into the frontal lobe. The accident has resulted from the thrust of a walking stick, umbrella or knife, from running against a pointed object in the dark, and from a bullet. Having the fatal character of this accident in view, the patient should be immediately anæsthetised, the wound in the eyelid enlarged and carefully examined by probing for a foreign body, septic material in the orbit, or for fracture of the orbital plate. Supposing the latter found, the eyelid should be further incised horizontally, below the

eyebrow, the eyeball gently depressed, then the roof of the orbit chipped away. If the dura is lacerated, the wound should be wiped out with an antiseptic and the cavity plugged with gauze changed daily, or a drain-tube inserted.

For other injuries of the eye see *Diseases of the Eye.*

Foreign bodies in the nose.—Peas, beads, buttons, pebbles, and the like are sometimes pushed up the nose by children, where they sooner or later give rise to irritation and a muco-purulent and fœtid discharge. Indeed the presence of such a discharge from one nostril in a child should always lead the surgeon to make a careful search, if necessary under an anæsthetic, for a foreign body. The collar-stud and portion of lace trimming, shown in Fig. 193, Walsham removed from the nose of a boy aged eight years. The boy had introduced them five years previously, and they had remained undetected, the discharge having been looked upon as catarrhal. If allowed to remain, foreign bodies become encrusted with earthy salts, forming so-called rhinoliths or nose-stones, and may set up inflammation and ulceration, or even bone disease. When surrounded by inflammatory granulation tissue they may readily be mistaken for a sarcoma. The use of a probe should, however, prevent such a mistake. The foreign body can generally be removed by forceps, curettes, hooks, or snares, after applying cocain. If in a restless child, chloroform is given, the mouth gagged open, and the finger inserted into the posterior nares. Then the foreign body can be extracted or pushed back into the naso-pharynx without danger of its getting into the larynx, pus, calcareous débris or necrosed bone being at the same time taken away.

Foreign bodies in the ear.—In dealing with these it should be borne in mind that the middle is the narrowest part of the meatus, and that they may be readily pushed beyond this, so rendering their extraction extremely difficult. They should be removed by syringing with tepid water, and no attempt made to extract them with instruments unless their nature is such that the warmth and moisture of the part may cause them to swell, as is the case with peas. Under these circumstances, some of the various aural curettes, snares, etc., devised for the purpose may be used, but with great gentleness and aided by artificial light, the child, if unruly, being placed under an anæsthetic. If a rounded body, as a bead, does not come away on syringing, a fine hook may be tried. The irritation of a foreign body or the incautious use of instruments has been attended by perforation of the membrana tympani, and even followed by fatal intracranial inflammation. As a caution, it may be mentioned that the handle of the malleus has ere now been mistaken for a foreign body and roughly torn out. In any case of difficulty, the meatus should be exposed by an incision in the fold behind the auricle, and the foreign body raised and extracted with great gentleness.

Fracture of the nasal bones is always the result of severe direct violence. The fracture is commonly transverse in direction, and is often comminuted and accompanied by much displacement and at times by emphysema. Rarely the fracture extends through the perpendicular plate of the ethmoid and thence to the cribriform plate. Hence it may be complicated by subsequent inflammation of the brain and its membranes. *Treatment.*—The bones should be manipulated into position by the fingers externally and by a director passed up the nostril, or by the dressing-forceps with one blade within and one blade outside the nose. The fragments should then be retained in position, which is often difficult, by pads of lint and strapping, or if such are insufficient by some form of nose truss, such as the author's (see *Diseases of the Nose*). They unite very quickly by bony callus. The septum, where this has been deflected, should be straightened so as to support the depressed bones, and kept in place by ivory plugs passed up the nostrils, or by other suitable retentive apparatus. Where the fracture has not been properly reduced much deformity may remain, and if the septum has also been deflected, considerable inconvenience may be felt in consequence of obstruction to respiration through one or other nostril. In such cases, though a considerable period may have elapsed from the time of the accident, much may be done by forcible straightening to remedy the deformity (see *Diseases of the Nose*). The lateral cartilages, if separated from the nasal bones, should be carefully replaced, as if this precaution is neglected little can subsequently be done, except by wiring or paraffin injection. Where, however, they are merely laterally deflected, the resulting deformity may be corrected by the use of a retentive apparatus.

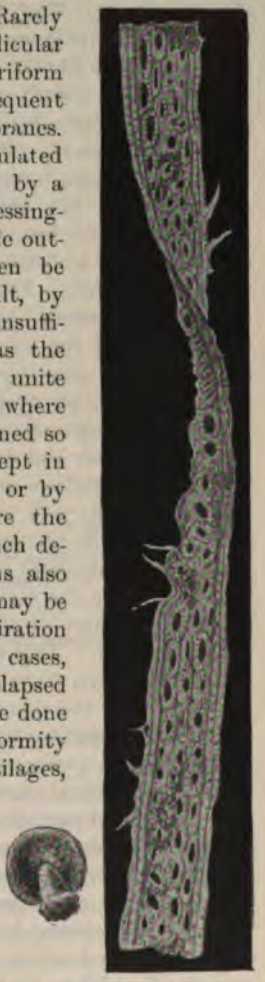


FIG. 193. — Collar-stud and lace trimming (exact size) removed from the nose. (St. Bartholomew's Hospital Museum.)

Fractures of the upper jaw, or of the malar bone, with depression of the zygomatic arch, are occasionally met with in severe smashes of the face. They are often impossible to rectify, and considerable deformity frequently remains. Although much comminution may occur, necrosis, in consequence of the great vascularity of these parts, rarely results. Walsham succeeded in raising the depressed zygomatic arch by

introducing an elevator subcutaneously beneath it. The depression may also be filled up by injecting paraffin wax.

Fracture of the lower jaw is nearly always due to severe and direct violence. The fracture may extend through any portion of the bone, but commonly occurs a little to one or other side of the symphysis, the line of fracture being then usually vertical. In this situation, and indeed whenever the fracture involves the alveolar border, the muco-periosteum of the gum is torn, rendering the fracture compound. It unites, however, nearly always like a simple fracture. Sepsis, however, may occur, when fœtid pus commonly escapes into the mouth and may set up septic pneumonia. Occasionally an abscess followed by a sinus may point externally, and at times a localised necrosis of the ends of the inflamed fragments ensues. There is not, as a rule, much displacement; but when, as sometimes happens, there is a fracture on both sides of the symphysis, the central portion is considerably depressed by the action of the genio-hyoid and digastric muscles, and the tongue falling back causes dyspnœa. When the line of fracture extends through the angle or ramus, the fragments are held in apposition by the masseter on the outer, and the internal pterygoid on the inner side. The fracture may occasionally pass through the coronoid process or the neck of the condyle. In the latter situation the displacement is peculiar, the condyle on the injured side being drawn forwards and inwards by the external pterygoid muscle of that side, while the rest of the jaw is tilted over towards the injured side by the action of the opposite external pterygoid, which is thus left unopposed. This sign is of some importance in distinguishing such a fracture from a unilateral dislocation, in which the jaw is drawn over to the side opposite the dislocation; or the lower fragment may penetrate the external auditory meatus, with rupture of the membrana tympani, or even fracture of the base of the skull. The inferior dental nerve is seldom torn, since, except in the fracture near the symphysis, there is not as a rule much displacement of the fragments. The incisor branch, however, may be divided along with the inferior dental artery, but serious hæmorrhage from this vessel is the exception. *Signs.*—The common form of fracture may be readily distinguished by pain increased on moving the jaw, dribbling of blood-stained saliva, some irregularity in the line of the teeth, unnatural mobility of the fragments, crepitus, and a rent in the mucous membrane over the fracture. Fracture through the angle may be detected by crepitus and by slight mobility of the fragments on firmly grasping the ramus and body of the jaw. Fracture through the neck may be known by the peculiar displacement before alluded to, and perhaps by crepitus on manipulation. *Treatment.*—The parts should be placed in apposition and kept at perfect rest. This can usually be done by a gutta-percha splint moulded to the chin (Fig. 194), and secured by a four-tailed bandage (Fig. 197).

All movements of the jaw must be avoided, the patient being fed on slops introduced either behind the last molar tooth or through any space left available by the loss of a tooth. The mouth should be frequently washed out, especially after feeding, with an antiseptic lotion, as weak Condy's fluid, to as far as possible prevent sepsis. In placing the parts in apposition some difficulty may be experienced in consequence of a displaced tooth having slipped between the fragments. If the parts cannot be kept in place by the simple splint above mentioned, they must be secured either by drilling the fragments and wiring them together, or by making a model and fitting to it the dental splint shown in the accompanying drawing (Fig. 195). The splint consists of a wire frame fitted round the back and front of the teeth, and further secured by transverse wires between the teeth. One of the so-called interdental splints may at times be found necessary. Acland's splint consists of two horseshoe-shaped concave metal plates, one fitting over the teeth

FIG. 194.—Gutta-percha splint for fractured jaw. (Bryant's Surgery.)

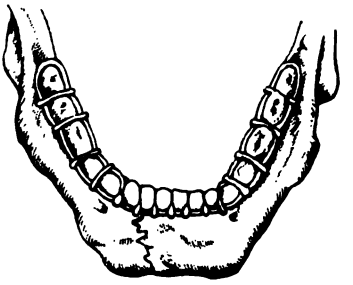


FIG. 195.—Dental splint applied.

in the mouth, the other under the chin, held together by two screw clamps. Should necrosis occur, the dead bone should be removed when loose, the sinuses in the meantime being frequently kept syringed with antiseptic lotion. Union takes place in four or five weeks.

Dislocation of the lower jaw.—This accident may sometimes result from a fall or blow upon the chin with the mouth open, but more frequently occurs from spasmodic action of the external pterygoid muscles during yawning. It has occasionally happened in extracting a tooth or tooth-fang. When both condyles are displaced the dislocation is said to be bilateral; when only one is displaced, unilateral. It is most common in women, in young women muscularly weak and anæmic, in old edentulous women in whom atrophy of the jaw has occurred. *Nature of displacement.*—The condyle with the inter-articular cartilage is drawn over the eminentia articularis into the zygomatic fossa, where it is firmly held by the contraction of the internal pterygoid, masseter, and temporal muscles. *Signs.*—The mouth is widely open and cannot be closed by any voluntary effort of the patient, and the saliva

constantly dribbles away. In bilateral dislocation the sym remains in the middle line, and an unnatural hollow is felt each condyle. If the dislocation is unilateral the symph carried over to the opposite side, and the hollow is felt beh the dislocated condyle. In either case the condyle or condyl be seen and felt in the abnormal position. *Treatment.*—Th cations are to overcome the contracted muscles, and so all displaced condyle or condyles to be drawn by the tempor deep fibres of the masseter, the retractors of the jaw, o eminentia articularis into their sockets. A cork, or the t wrapped in a towel to avoid being bitten, should be placed b the last molar teeth of the upper and lower jaw on each side as a fulcrum, while pressure is made in an upward direction symphysis by the surgeon's hands on the principle of a lever of the first order (Fig. 196). Whilst the symphysis is thus pushed upwards the condyle is

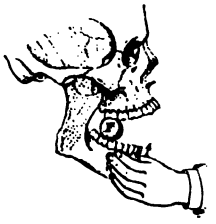


Fig. 196.—Mechanism of reduction of a dislocated jaw. F. Cork acting as The dotted lines represent the masseter and temporal muscles—the wei overcome by the hand or power.

Fig. 197.—The four-tailed bandage applied. (Bryant's Surgery.)

drawn downwards, the weight, represented by the contracted m being gradually overcome. As soon as the condyle is clear eminentia articularis it is drawn back into its place with by the fibres of the retractor muscles. At times, in cons it would appear of the coronoid process being wedged agai zygoma, reduction cannot be effected in this way. Downw backward pressure by the protected thumbs on the coron cesses will then generally succeed. A four-tailed bandage (F should be worn for a fortnight to prevent re-dislocation, w very liable to happen.

The term **subluxation of the jaw** is applied to a sli placement of the inter-articular cartilage which limits move an unnatural slipping forwards of the inter-articular cartilag eminentia articularis in consequence of rupture or elongatio ligaments. The latter condition is most frequently met delicate young people. The condyle catches, and the mouth

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d is through the cartilages, the vocal cords and one or
of the intrinsic laryngeal muscles may be divided, with con-
nt loss of voice; the cartilages themselves, moreover, may be
sly displaced. There is as a rule but little hæmorrhage.
hen the wound is made below the cricoid cartilage, the depressor

constantly dribbles away. In bilateral dislocation the symphysis remains in the middle line, and an unnatural hollow is felt behind each condyle. If the dislocation is unilateral the symphysis is carried over to the opposite side, and the hollow is felt behind only the dislocated condyle. In either case the condyle or condyles can be seen and felt in the abnormal position. *Treatment.*—The indications are to overcome the contracted muscles, and so allow the displaced condyle or condyles to be drawn by the temporal and deep fibres of the masseter, the retractors of the jaw, over the eminentia articularis into their sockets. A cork, or the thumbs, wrapped in a towel to avoid being bitten, should be placed between the last molar teeth of the upper and lower jaw on each side to act as a fulcrum, while pressure is made in an upward direction on the symphysis by the surgeon's hands on the principle of a lever of the first order (Fig. 196). Whilst the symphysis is thus pushed upwards the condyle is

Fig. 196.—Mechanism of reduction of a dislocated jaw. *r.* Cork acting as fulcrum. The dotted lines represent the masseter and temporal muscles—the weight to be overcome by the hand or power.

Fig. 197.—The four-tailed bandage applied. (Bryant's Surgery.)

drawn downwards, the weight, represented by the contracted muscles, being gradually overcome. As soon as the condyle is clear of the eminentia articularis it is drawn back into its place with a snap by the fibres of the retractor muscles. At times, in consequence it would appear of the coronoid process being wedged against the zygoma, reduction cannot be effected in this way. Downward and backward pressure by the protected thumbs on the coronoid processes will then generally succeed. A four-tailed bandage (Fig. 197) should be worn for a fortnight to prevent re-dislocation, which is very liable to happen.

The term **subluxation of the jaw** is applied to a slight displacement of the inter-articular cartilage which limits movement to an unnatural slipping forwards of the inter-articular cartilage on the eminentia articularis in consequence of rupture or elongation of the ligaments. The latter condition is most frequently met with in delicate young people. The condyle catches, and the mouth cannot

be closed for a second or two, but it can generally be replaced by the patient's voluntary efforts with a distinct snap. *Treatment.*—If counter-irritation and tonics do not succeed the joint may be opened and the cartilage secured in position by sutures or removed.

INJURIES OF THE NECK, INCLUDING THE ENTRANCE OF FOREIGN BODIES INTO THE PHARYNX, ŒSOPHAGUS AND AIR-PASSAGES.

Wounds of the neck.—These are punctured, superficial, and deep incised wounds.

The *punctured* and *superficial* wounds are chiefly important from injuring arteries and veins, and have been treated of under these headings.

Deep incised wounds or cut-throat.—They are rarely accidental, but are generally inflicted either with suicidal or homicidal intent. They may be situated anywhere between the lower jaw and the sternum, especially in the neighbourhood of the thyroid cartilage owing to its prominence. One or more gashes may be present, with chippings or partial fracture of the cartilages and injuries of the large vessels, or the incisions may go down to the spine. Lateral wounds are less frequent and more immediately fatal, since they divide the carotid artery and jugular vein. Posterior wounds are the rarest, but a suicide has succeeded in reaching the spinal canal between the occiput and atlas by a transverse cut with a razor. The characters of the wound considered alone are very uncertain guides in determining the origin, whether homicidal, suicidal, or even accidental (see a work on Forensic Medicine). Broadly speaking, the wounds inflicted may be compared with those made in the various operations, pharyngotomy, thyrotomy, laryngotomy, tracheotomy. Thus, 1. When the wound is made above the hyoid bone the tongue may be partly severed, and the muscles that depress the jaw and elevate the hyoid bone divided together with the lingual or facial arteries and hypoglossal nerve. Such a wound will gape widely, and may open into the mouth, the food and saliva then escaping freely through it. 2. When the wound is through the thyro-hyoid membrane, the most common situation, the pharynx will be opened and the epiglottis, aryepiglottidean folds or arytenoid cartilages, the superior thyroid and lingual arteries, and the superior laryngeal nerve may be cut through. The wound gapes less than in the preceding situation, but allows of the escape of food and saliva. There is usually great difficulty in swallowing. 3. When the wound is through the cartilages, the vocal cords and one or other of the intrinsic laryngeal muscles may be divided, with consequent loss of voice; the cartilages themselves, moreover, may be variously displaced. There is as a rule but little hæmorrhage. 4. When the wound is made below the cricoid cartilage, the depressor

muscles of the larynx, the inferior or superior thyroid artery, and the thyroid and anterior jugular veins may be wounded, the recurrent nerve divided, paralysing the vocal cord, the trachea partly or entirely cut across, and even the œsophagus implicated.

Wherever the wound is situated the carotid arteries owe their escape to the resistance of the cartilages of the larynx, the deep situation of the carotids, and the contraction of the sterno-mastoid muscles. The sheath or outer coat may be just nicked.

Dangers.—The immediate dangers are—1. *Hæmorrhage.* When the carotid artery or jugular vein is wounded death is generally, though not invariably, instantaneous; but even when no large vessel is implicated, death before help is obtained is frequent from hæmorrhage from some of the arteries above mentioned, the external jugular vein, etc. 2. *Obstruction to respiration* in consequence of (*a*) the blood entering the air-passages in larger quantities than the patient can cough up; (*b*) the rolling back of the tongue over the glottis; (*c*) the displacement of the cartilages; (*d*) the separation of the divided portions of the trachea. 3. *Entrance of air into the veins* is also an occasional danger. *The subsequent dangers are*—1. Œdematous laryngitis; 2. Bronchitis and broncho-pneumonia, due in part to admission of cold air and in part to sepsis; 3. Septic inflammation of the loose tissues of the neck (*cellulitis*), even extending to the mediastinum or pleura, and perhaps giving rise to secondary hæmorrhage; 4. Septic traumatic fever; 5. Surgical emphysema extending from the neck to the trunk; and still later, 6. Obstruction of the air-passage with increasing dyspnœa or loss of voice from (*a*) constriction during cicatrisation, or (*b*) formation of prominent granulations; and 7. Œsophageal or tracheal fistula.

Treatment.—The hæmorrhage must be arrested; the air-passages cleared when obstructed with blood, by suction if necessary; and artificial respiration resorted to if the patient has already ceased to breathe. Saline solution should be injected into the rectum or into the veins if the hæmorrhage and shock are severe. If the tongue or epiglottis is divided it must be fixed by sutures, or if a portion of the epiglottis is loose it may be cut off. The wound is rendered as aseptic as possible, then closed with sutures, completely as far as regards the mucous membrane, cartilages, and muscles. A fine suture through the sheath or outer coat of the carotid if nicked may be inserted. The skin is partly drawn together, and the wound partly filled by gauze, including especially dependent pockets, avoiding by this means emphysema and septic collections; the patient being propped up by pillows and the head bent forwards so as to relax tension. The cartilages of the larynx, if displaced, may be brought together by suture, as may also the trachea, if divided, but a tracheotomy tube had better be left in for a few days between the stitches. When the œsophagus is wounded the edges

may be united by suturing the muscular coat, the mucous membrane being turned inwards, and the patient fed by a tube passed through the mouth and beyond the wound, or at first entirely by the rectum. Tracheotomy may have to be performed if respiration is embarrassed by displacement of the laryngeal cartilages or by œdema of the glottis. When the air-passages are opened the precautions described under *Tracheotomy* must be taken to prevent lung-trouble. Suppuration must be looked for, and free exit given to pus as soon as detected. The patient, if a suicide, should, of course, be carefully watched.

Contusion of the larynx may be *caused* by blows or kicks of all kinds, or by manual compression as in garrotting. *Symptoms.*—Pain, especially on handling, localised swelling or ecchymosis, alteration or loss of voice, and slight hæmoptysis when the mucous membrane is lacerated. Unless there is much bleeding there is usually no dyspnœa, though this may subsequently be present should spasm or œdema of the glottis supervene. Severe compression of the larynx is said at times to have been instantly fatal from spasm of the glottis. The *treatment* should be directed towards allaying pain and preventing inflammation. Thus, a lead and opium lotion or an ice-bag may be applied over the larynx, and all attempts at speaking prohibited. Should signs of œdematous laryngitis appear, leeches, followed by hot fomentations, may be placed over the thyroid cartilage, whilst scarification of the glottis, and if this fails and suffocation threatens, intubation of the larynx or tracheotomy must be performed.

Subcutaneous rupture of the trachea is a rare accident, but may be caused by any violence applied to the neck. It is attended by emphysema and dyspnœa, and is usually rapidly fatal. An incision should be made in the middle line of the neck and an attempt made to draw the lower end of the trachea to the surface, and to pass in a tracheotomy tube, or unite the ends by suture.

Fracture and dislocation of the hyoid bone.—*Fracture* may be produced by any violence applied to the neck, especially a severe grip. The line of fracture is usually about the junction of the greater cornu with the body, but may occur in any situation. The usual signs are pain, increased on handling, on turning the head, and on moving the tongue; dysphagia or inability to swallow; hoarseness or aphonia; a sense of suffocation on protruding the tongue; mobility of the fragments and crepitus; sometimes cough and dyspnœa; hæmoptysis when there is laceration of the mucous membrane; and occasionally, later, signs of œdema of the glottis. *Treatment.*—The fragments should be replaced by the forefinger passed through the mouth, whilst the fingers of the other hand manipulate the bone externally, a gag and chloroform being usually necessary. The neck must then be kept perfectly quiet between

sand-bags or in a poroplastic collar, and the patient fed on slops passed well to the back of the tongue.

What has been described as *dislocation* of the hyoid bone appears rather to be a condition of the parts due to relaxation of the ligaments attaching the thyroid cartilage to the hyoid bone, especially in tuberculous patients.

Fracture of the cartilages of the larynx.—The fracture may extend through either the thyroid or the cricoid cartilage, or through both. The thyroid alone is most usually fractured. *Cause.*—Direct violence applied to the part, such as a blow or a fall, or compression with the hand as in garrotting. The usual *signs* are pain, increased on speaking, on swallowing, and on handling; dyspnœa; cough; expectoration of frothy blood, and later, when inflammation has come on, of offensive pus; emphysema when the mucous membrane is injured; great swelling and ecchymosis; and on examination, irregularity, undue prominence or flattening of the cartilages, crepitus, and preternatural mobility.

The danger to be apprehended is obstruction to the respiration in consequence of—1, displacement of a portion of cartilage across the larynx; 2, spasm of the glottis from irritation of the fragments; 3, entrance of blood into the air-passages; 4, swelling from submucous extravasation of blood; 5, œdematous laryngitis; and 6, perichondral abscess and necrosis of the cartilage.

Treatment.—If the parts are fairly in apposition all that can be done is to steady them with a bandage and suitably-shaped pads of lint. But when there is serious displacement with perforation of the mucous membrane, as evidenced by severe dyspnœa and spitting of blood, tracheotomy should be *at once* performed, as otherwise the patient runs an imminent risk of sudden suffocation. An attempt may then be made, with the hand manipulating the cartilage externally, and by pushing a sponge or forceps upwards through the tracheotomy wound, whilst the forefinger of the other hand is in the pharynx, to rectify the displacement.

Injuries of the Pharynx and Œsophagus from within.

Wounds of the pharynx are not infrequently met with from falls with a pipe, stick, or pencil in the mouth. They may be attended by severe hæmorrhage when the lateral walls of the pharynx are punctured, either immediately, or on removing the inflicting body, or later, from a portion of the stick or pipe being broken off and remaining as a foreign body in the wound where it has caused suppuration and ulceration of a branch or the main trunk of the carotid or internal jugular.

Treatment.—Any bleeding vessel seen should be secured, or failing this, pressure must be made with a stick wrapped round

with lint. As a last resource the common or external carotid or jugular vein must be tied. Should a foreign body be seen in the wound it should not be removed till preparations have been made (as for tying the carotid) to effectually arrest any hæmorrhage which might follow its extraction.

Injuries of the œsophagus may be inflicted in attempts to remove a foreign body or to pass an œsophagus bougie; or its walls may be perforated by a fish-bone, in juggling with a sword, etc., or may occasionally be ruptured during vomiting. Fatal hæmorrhage from the aorta, also perforation of the pericardium, pleura, and posterior mediastinum, followed by empyema and death, have occasionally resulted from such injuries. *Treatment.*—Where a wound is suspected, the patient should at first be fed entirely by the rectum, and subsequently given only fluids in small quantities, so as to allow the wound time to heal, whilst the chest is frequently examined.

Burns and scalds.—Burns of the pharynx occasionally occur from the inhalation of flame, as in a gas explosion or from the clothes taking fire; scalds are more common, especially among the children of the poor, from drinking boiling water or inhaling steam from the spout of a tea-kettle. In neither of these injuries is the œsophagus as a rule involved. In the case of burns the flame sometimes appears to be drawn through the larynx into the trachea. The boiling water is generally ejected from the mouth and nose, and only affects the entrance of the larynx. Both burns and scalds owe their gravity to the fact that they are frequently followed by œdematous laryngitis. The scalded and white appearance of the mucous membrane and the history of the case generally make the diagnosis plain. *Treatment.*—The patient should be placed in bed in a warm room and carefully watched for signs of œdematous laryngitis. Should such supervene, the swollen mucous membrane at the entrance of the larynx may be scarified; but if this does not at once relieve, an O'Dwyer's tube should be placed in the glottis, or tracheotomy performed. In the slighter cases the application of a hot sponge to the neck, steam inhalations, lozenges of morphine and ipecacuanha, or of cocain, also the administration of small doses of tincture of aconite or calomel, may be tried.

Charring and certain chemical lesions from drinking corrosive liquids, strong acids, or alkalies, are not uncommon. The effects vary according as such liquids are taken intentionally or accidentally. In the former case, the larynx usually completely escapes, whilst the mouth, pharynx, œsophagus, and stomach, may be extensively injured. In the latter case, the fluid, on the discovery of the mistake, is expelled forcibly, and some of it thereby generally enters the larynx and nasal cavities, but little passes down the œsophagus. Here, as in burns and scalds, the chief immediate danger to be apprehended is œdematous laryngitis and

perforation. For an account of the effects that may follow swallowing corrosive fluids, the reader is referred to a work on Forensic Medicine. It need only be remarked here that should the patient recover from the immediate dangers, he may subsequently come under the care of the surgeon for stricture of the œsophagus or pylorus, due to the cicatrisation following the injury.

Foreign bodies in the pharynx and œsophagus.—Fish-bones, coins, tooth-plates, and portions of food are the bodies most commonly impacted in the pharynx and œsophagus. The situations at which they may become arrested vary with the nature of the body. Fish-bones, pins and the like are easily caught in the loose folds about the tonsil and fauces, or may be impacted lengthwise across the pharynx. Larger bodies, as tooth-plates, coins, etc., commonly become lodged about the cricoid cartilage (see Fig. 198) but may be arrested opposite the bifurcation of the trachea or at the cardiac entrance of the stomach. Coins pass or are arrested according to the size and the age of the patient: a half-penny may stick in a child's œsophagus, a half-crown pass through that of an adult. If not removed, they may either become loosened by ulceration and be expelled by the mouth or pass into the stomach, or they may lead to perforation and implication of a large blood-vessel or the pericardium, or set up septic inflammation in the posterior mediastinum. The *symptoms* and *treatment* vary according to the nature and size of the foreign body. A large portion of meat arrested over the entrance of the larynx will give rise to urgent symptoms of suffocation (Fig. 202); and endeavours should be made to remove it instantly by the finger plunged into the throat. If this fails, laryngotomy should be done at once, and artificial respiration resorted to if the patient has already ceased to breathe. A fish-bone or pin may give rise to a pricking sensation with difficulty or pain on swallowing, and the patient will often be able to indicate the position where it has lodged. A search should be made for it in the mouth and throat, aided by the laryngoscopic mirror, or if it cannot be thus found, by the *x* rays; but it must not be forgotten that the symptoms in consequence of the body having scratched the mucous membrane may persist even after it has been dissolved or swallowed. The position of a metallic body such as a pin or coin can be very accurately made out by the aid of the *x* rays (see Fig. 198). In the œsophagus a foreign body has been seen through a straight tube, œsophagoscope, the patient being anæsthetised and the head hanging low. If in the tonsil or about the fauces, it may be removed with the dressing-forceps, or it may be hooked out from the upper part of the pharynx by the finger-nail. In the case of any adult seized with dyspnœa at meal-times, the finger should be promptly thrust into the throat, and this is always the first thing to do for a child, for besides foreign bodies, sticky mucus, threatening suffocation, has been hooked out. If a foreign body is beyond reach

of the finger, an attempt must be made to extract it by pharyngeal forceps (Fig. 199) or by some of the various forms of coin-catchers

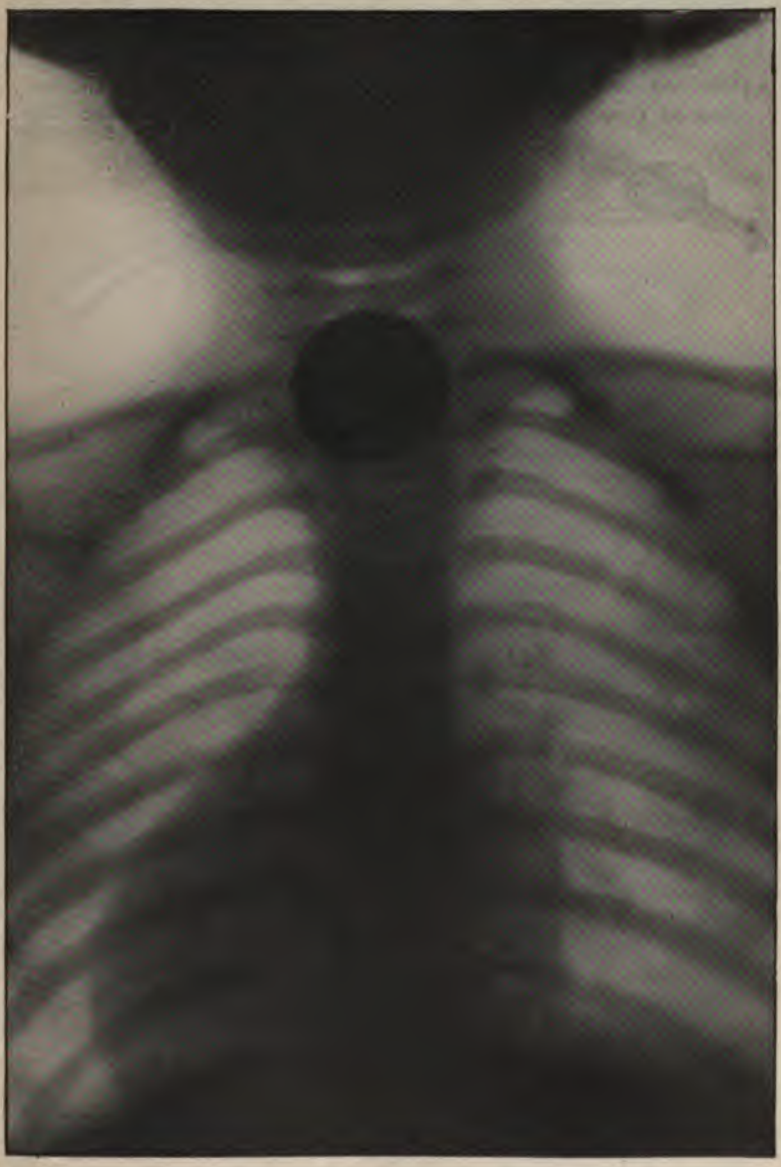


Fig. 198.—Skiagram of a halfpenny impacted at the commencement of the œsophagus. (Taken by Dr. Hugh Walsham.)

(Fig. 200), or the expanding horsehair extractor (Fig. 201). The coin-catcher is a most useful instrument for the removal of a coin impacted in the upper part of the œsophagus. It is passed just beyond the foreign body, and in withdrawal the moveable ring catches the body, which is then pulled up. If, after a thorough trial, guided by the *x* rays or œsophagoscope, with the patient under chloroform, these means fail, pharyngotomy must be performed, and the body removed through the opening in the neck. When situated lower

Fig. 199.—Pharyngeal forceps.

Fig. 200.—Coin-catcher and sponge probang.

Fig. 201.—Expanding horsehair extractor.

down the œsophagus, and it cannot be extracted, or pushed on by gentle means, an endeavour must be made to extract it by œsophagotomy (*vide infra*). In such manipulations the greatest care must be taken, since if the body is sharp the œsophagus may easily be lacerated. When the foreign body has been pushed into the stomach purgatives should *not* be given, but the patient should be fed on oatmeal porridge, brown bread, etc., in the hope that the body, if angular, may become surrounded by this soft material and travel through the intestines without injuring them. Should it be too large to pass the pyloric valve, gastrotomy is required. When impacted at the cardiac end of the stomach, the stomach may be opened, the cardiac orifice dilated, and the foreign body removed by forceps or by the hand.

Foreign bodies in the air passages.—A foreign body may become lodged in the larynx, the trachea, or in one of the bronchi.

Foreign bodies in the larynx.—A foreign body may be lodged above, below, or between the vocal cords, or in the ventricles. When a voluminous body, as a piece of meat, becomes impacted at the entrance of the larynx, it may block up the passage, causing instant suffocation (Fig. 202). Smaller bodies, wherever situated, may also cause fatal dyspnœa, by setting up reflex spasm of the muscles of the glottis; though in some cases a foreign body, such

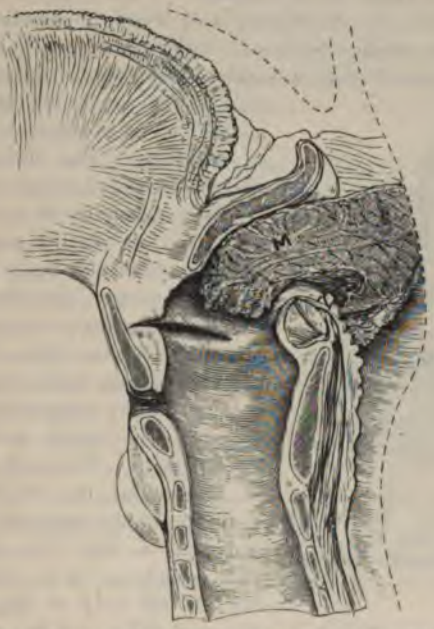


Fig. 202.—A portion of meat, M, firmly impacted in the entrance of the larynx. (St. Bartholomew's Hospital Museum, No. 1660 *a*.)

as a tooth-plate, may be so lodged between the cords, as to prevent them closing. A foreign body in the ventricle may cause the same urgent symptoms. At other times the foreign body may give rise to severe, but not fatal, attacks of dyspnœa and spasmodic cough, though if not removed, inflammation and œdema will probably be set up, and the patient ultimately succumb. If it cannot be seen by the aid of the laryngoscope, its exact location may often be made out by the *x* rays. *Treatment.*—Where the symptoms are urgent and the body cannot be removed by the finger, instant laryngotomy should be performed. But when less urgent a deliberate attempt should be made to remove it by means of laryngeal forceps aided by the laryngoscope, preparation having been made for instant

tracheotomy lest sudden spasm of the glottis be set up by the manipulation. Sometimes, where extraction would be otherwise impossible, this may be accomplished by cutting the body in two by the use of the laryngeal cutting-pliers. These means having failed, an external operation must be undertaken. Thus, when the foreign body is above the cords, it may be removed by sub-hyoid pharyngotomy; when between the cords or in one of the ventricles by thyrotomy; when below the cords, by laryngo-tracheotomy or tracheotomy, the forceps in the last instance being passed up through the wound in the trachea.

Foreign bodies in the trachea and bronchi.—Small objects such as coins, buttons, orange-pips, and fruit-stones, are liable to be drawn into the trachea during a sudden inspiration, while the patient is swallowing or is holding such in his mouth. The accident is most common in children. The foreign body may remain free or become impacted either in the trachea or in a bronchus (Fig. 203). It is usually said to most frequently enter the right bronchus, that being the larger, and the spur-like projection at the bifurcation of the trachea directing it that way; but the left is the more direct route, and the direction it takes would seem to depend in great part on the shape and size of the foreign body. Thus an elongated body as the metal cap of a cedar pencil would probably enter the left, a rounded body, as a coin, the right bronchus. The *symptoms* vary somewhat, according as the body is free or impacted, light or heavy. When it is free and light, and has either remained in the trachea, or, as is usually the case, has fallen into one of the bronchi, there will be sudden and paroxysmal attacks of suffocative cough and dyspnœa, in consequence of the foreign body being driven upwards against the glottis, which then closes spasmodically. On listening over the trachea it may be heard to strike the cords, whilst a tracheal râle may sometimes be detected, or, as it passes up and down, a whistling sound. During the intervals of the cough and dyspnœa, whilst the body is at rest in the bronchus, as is also the case when it is permanently impacted in it, there will be an absence of the breathing sounds over the whole or part of the lung on that side, according as the main bronchus or one of the secondary bronchi is obstructed; the resonance, however, will be normal or dull in places, according to the position and nature of the foreign body. If any air can pass the obstructing body, rhonchial or sibilant sounds

FIG. 203.—Foreign body in the right bronchus. The trachea is opened from the front. (St. Bartholomew's Hospital Museum.)

may be heard, due in part to the bronchitis set up by it. Over the opposite lung puerile breathing may be detected. When the foreign body is heavy and of a rounded shape, it may act as a ball-valve, *i.e.*, it may allow air from the lung to be forced past it during expiration, but then fall back into a narrower part of the bronchus, and so prevent air entering during inspiration. In this way collapse of the whole or part of the lung may be brought about. By the *x* rays the position of the foreign body may sometimes be made out. If the foreign body is not removed, or does not escape spontaneously, sudden death may occur during an attack of spasmodic dyspnœa: or it may set up bronchitis, pneumonia, or gangrene or abscess of the lung. At other times it induces more chronic changes, such as phthisis, or it may become encysted and no harm follow. In rare instances it may make its way out through the chest-walls by perforation or ulceration.

Treatment.—The patient should be inverted. Before doing this, however, everything should be in readiness for instant tracheotomy, in case the foreign body becomes lodged in the larnyx and gives rise to spasm of the glottis. Children may be held up by the legs, but for adults it is necessary to tie them to a table that can be tipped up Inversion failing, tracheotomy should be performed, as the patient is in danger of suffocation at any instant. The opening in the trachea is best made below the isthmus, and should be free; if the foreign body be not expelled at once, either through the wound, or, as sometimes happens, through the mouth, the patient may be again inverted, or search made for it through the wound with tracheal forceps, wire variously bent, a coin-catcher, etc. These means failing, the tracheotomy wound must be kept open to allow of future trials being made should the foreign body not be expelled during the interval. If an abscess in the lung forms about the foreign body, it must be opened through the chest-wall and the body, if found, removed.

Pharyngotomy or œsophagotomy is the operation of opening the lower part of the pharynx or upper part of the œsophagus for the purpose of removing a foreign body. As the œsophagus inclines to the left, the operation by choice is done on that side, unless the body be felt distinctly on the right side. Make an incision about four inches long, having its centre opposite the cricoid cartilage, parallel to the sterno-mastoid, over the interspace between the great vessels and the larynx. Divide the platysma and deep fascia; draw the sterno-mastoid outwards, and the sterno-hyoid and sterno-thyroid inwards; and divide the omo-hyoid if in the way. Gently draw the larynx and trachea across the middle line in order to separate them from the great vessels; and then open the pharynx or œsophagus, as the case may be, by cutting on the foreign body if felt, or on the point of a sound passed through the mouth and made to project in the wound through the œsophagus low in the neck. Avoid injuring

the superior and inferior thyroid arteries and the recurrent laryngeal nerve. If the foreign body is situated a little below the upper opening of the thorax, an attempt may be made to remove it by forceps passed into the œsophagus through the wound. The incision in the œsophagus should be united by sutures, avoiding the mucous membrane. The external wound should then be filled with iodoform gauze, and dressed antiseptically. The patient should be fed entirely by the rectum for some days after the operation, or by a tube passed down the œsophagus and retained *in situ*.

Opening the œsophagus in the posterior mediastinum has been proposed for the extraction of a foreign body in the thoracic portion of the tube, by cutting vertically through the third, fourth, and fifth ribs between the scapula and spine, so reaching the posterior mediastinum.

INJURIES OF THE CHEST.

Injuries of the Chest-walls.

Contusions may be produced by any sort of violence applied to the chest, and may be attended with laceration or rupture of the muscles, or with extravasation of blood into the tissues, which, again, may be followed by suppuration and abscess. They owe their chief importance, however, to the fact that they may be complicated by serious injury to the contained viscera, such as contusion or laceration of the pleura, lung, pericardium, or heart, or rupture of a large vessel in the mediastina. In some cases of severe contusion, in which death has occurred immediately or soon after the injury, without any lesion being found, the fatal result may be due to direct pressure on the heart, vagus, or sympathetic, or to anæmia of the brain due to a sudden fall of blood-pressure.

Fracture of the ribs is a very common accident. *Cause.*—Generally external violence, rarely muscular action. 1. *External violence* may be—(*a*) *Direct*, such as the kick of a horse, a fall upon the edge of a table, etc. The fracture then occurs at the seat of injury, the fragments being driven inwards, occasionally injuring the thoracic, or more rarely, the abdominal viscera, especially the liver or the diaphragm; or (*b*) *Indirect*, as the severe compression of the chest in a crowd. The fracture then generally occurs about the angle of the ribs, their most complex part, and several bones are usually broken. 2. *Muscular action.*—The ribs are sometimes broken in this way during violent coughing, or from straining during parturition.

Complications.—Fractures of the ribs may be complicated by an external wound; a wound of the pleura and lung, or pericardium and heart; laceration of a blood-vessel, as an intercostal artery; penetration of the diaphragm; and more rarely by perforation of

the peritoneum, and wound of the liver or spleen. Hence they may be followed by emphysema, pneumothorax, hæmothorax, hæmoptysis, hæmopericardium, and later by pleurisy, pneumonia, pericarditis, or peritonitis.

State of the parts.—Fracture of the ribs is more common in the old than in the young, on account of the loss of elasticity as age advances, and is frequent in general paralysis and in the insane. Like fractures of other bones, they may be simple, compound, or comminuted. The middle ribs (fifth to eighth) are those usually affected; the first and second rib being protected by the clavicle, and the eleventh and twelfth being moveable, are not often broken. Fracture of the upper ribs is more serious than fracture of the lower, as the lung is more liable to be wounded.

Signs.—Severe stabbing pain is felt over the seat of fracture, and is increased on taking a deep breath or on coughing. On drawing the finger along the rib, some irregularity may be detected. Crepitus is usually felt on placing the hand flat over the fracture while the patient breathes deeply, or it may be heard on listening with the stethoscope. When several ribs are broken there may be a distinct depression in the chest-walls. Emphysema, *i.e.*, a crackling sensation, something like rubbing the hair between the fingers, may at times be felt on touching the part. It is nearly always due to a wound of the lung, the air being drawn into the pleura through the visceral layer during inspiration, and forced through the wound in the parietal layer into the subcutaneous tissue during expiration.

Treatment.—In an ordinary case the injured side should be strapped with strips of adhesive plaster, so as to control the respiration on that side, and thus place the fractured rib as much as possible at rest. A broad bandage in addition applied round the chest often gives relief. When several ribs are broken, a shield of gutta-percha may be moulded to the chest-walls and strapped on. Union occurs by ensheathing callus in three or four weeks.

Fracture of the costal cartilages and **separation** of the **cartilages** from the ribs or sternum is sometimes met with. Union occurs by bone in each case. The symptoms and treatment are the same as in fractured ribs.

Fracture of the sternum is rare. It may be accompanied by fracture of the ribs or costal cartilages, separation of the ribs from their cartilages, and sometimes by fracture of the spine.

Causes.—Direct violence; indirect violence in consequence of a forcible bend of the body either backwards or forwards, in fracture of the spine; very rarely muscular action, as during parturition.

State of the parts.—The line of fracture generally runs through the gladiolus, and may be transverse, oblique, or longitudinal, the lower fragment usually projecting in front of the upper; but at

times the gladiolus is separated from the manubrium, a condition sometimes spoken of as *dislocation of the sternum*. The chief *signs* are pain, increased on deep inspiration and coughing, irregularity and crepitus at the seat of fracture, emphysema if the lung is wounded, and severe dyspnœa if the upper fragment compresses the trachea. The fracture may be complicated by injury of any of the thoracic viscera, or by hæmorrhage or suppuration in the anterior mediastinum, and later by aneurysm of the aortic arch. *Treatment*—Retraction of the head and shoulders will remedy the displacement; then rest on the back, and the application of a bandage, if it can be borne, round the chest, or simple strapping as in fracture of the ribs.

Wounds of the chest-walls may be divided into the penetrating and non-penetrating. The *non-penetrating* are of no serious consequence, and may be treated like wounds in other situations. The *penetrating* are those that pass through the parietes into the pleura, pericardium, or mediastinum, and may be complicated by a wound of the lung, the heart, a large blood-vessel, an intercostal artery, or the internal mammary artery. They are produced by bullets and by stabs. When the wound is small, and there are no signs of injury to the thoracic viscera, it is not always possible to determine whether it has penetrated the chest-wall; although the direction and situation of the wound, and an account of the way in which it was inflicted, may point to its having done so. Under these circumstances, the skin around the wound should be rendered aseptic, and the hands having been purified, a finger should be cautiously passed into the wound, which may be enlarged if necessary, and any loose fragments of a fractured rib, portions of clothing or other foreign body if felt removed. If the chest is found to be perforated, the case should be treated according to the nature of the injury (see *Injuries of the Contents of the Chest*). If perforation has not occurred, the treatment will be that of other wounds.

Injuries of the Contents of the Chest.

These may be divided into injuries of the—1, pleura and lung; 2, pericardium and heart; and 3, large blood-vessels.

1. **Injuries of the pleura and lung.**—*Contusion of the lung* without an external wound may be produced by a severe crush of or blow upon the chest, and is not infrequent in fracture of the ribs. The visceral layer of the pleura may or may not be lacerated. It is attended with some shock, severe pain, paroxysmal dyspnœa, cough, and slight hæmoptysis, followed in a few days by localised dulness, crepitation, and expectoration of rusty sputa. If the visceral layer of the pleura is lacerated, blood and air may escape into the pleura cavity, and there will then be, in addition to the above, signs of hæmo-pneumothorax. The patient usually recovers

in a few days, but pneumonia, pleurisy, or even abscess or gangrene of the lung occasionally ensues.

Wounds of the pleura and lung may be produced by the fragments of a broken rib, or by a stab or gunshot. When attended with a penetrating wound of the chest they are very serious. The pleura alone may be wounded, but more often the lung is injured at the same time. *Signs.*—No single symptom is sufficient to make it certain that the lung has been wounded; but where several of the following are present, the diagnosis becomes fairly certain. Thus, there may be marked shock, severe pain, abdominal breathing, and cough with expectoration of frothy blood-stained mucus, or even of pure blood. If there is an external wound, there will be escape of air intimately mixed with blood, and accompanied by a peculiar hissing noise (*hæmatopnœa*); or if there is no external wound, emphysema in the region of the fractured rib. When the pleura alone is injured, a very rare accident, the signs are similar; but no blood is coughed up, and though air may escape from the external wound if there be one, it is not churned into a fine froth with the blood, as it does not come from the lung, but is simply drawn in and out of the pleura through the wound in the parietes during inspiration and expiration. *Complications.*—Hæmothorax, pneumothorax, emphysema, hæmorrhage, and later pleurisy and pneumonia (see *Complications of Injuries of Chest*). *Treatment.*—Absolute rest, ice to suck, opium to subdue pain, closure of the wound if small, or insertion of drain tube if large, and antiseptic dressings, with such treatment as is appropriate for the complications that may be present (see below). If the pleura alone is injured, the external wound should be closed, unless any complication exists, and dressed antiseptically. If the wound is large and the bleeding from the lung continues, the lung may be exposed and the hæmorrhage stopped by ligature or plugging.

2. **Injuries of the heart and pericardium.**—*Contusions, wounds, and rupture of the pericardium* may at times be produced by a severe crush of the chest-walls; but are more often due to the penetration of a fragment of a broken rib, or to a stab or gunshot. In the last two instances the heart is generally also involved. *Signs.*—Severe shock, hæmorrhage, the position and direction of the wound, and subsequently symptoms of pericarditis. The prognosis is always very serious, death usually occurring either from the effused blood impeding the heart's action, or from pericarditis. The *treatment* consists in absolute rest, the local application of cold, and if inflammation threatens, of leeches. Should the heart's action become seriously impeded by effused blood, serum, or pus, aspiration or free incision and drainage may be required. When there is an external wound it should be dressed antiseptically, the pericardium being sutured if practicable.

Wounds of the heart, especially when they penetrate one of its

cavities and particularly an auricle, are generally instantaneously fatal from shock or hæmorrhage. Remarkable exceptions, however occur, and patients have been known to linger for a few hours or a few days, or even to recover. *Signs.*—When not at once fatal, a wound of the heart is attended with great collapse, syncope, a fluttering pulse, and dyspnœa, and later with symptoms of pericarditis. The *treatment* is the same as that for a wound of the pericardium. Recently wounds of the heart have been sutured with some success after enlarging the wound of the pericardium.

Rupture of the heart, though rare, occasionally occurs as the result of great external violence to the chest-walls, or of some sudden exertion on the part of a patient suffering from disease of the heart's substance. Death is as a rule almost instantaneous.

3. **Wounds of the large blood-vessels,** as the aorta or vena cava, are almost invariably and immediately fatal, and require no further comment here.

Complications of Injuries of the Chest.

The chief complications attending injuries of the chest are :—1, external hæmorrhage ; 2, hæmoptysis ; 3, hæmothorax ; 4, pneumothorax ; 5, emphysema ; 6, prolapse and hernia of the lung ; 7, injuries to the diaphragm and abdominal viscera.

1. **External hæmorrhage** in penetrating wounds of the chest-walls may come from :—(1), an intercostal artery or the internal mammary artery ; (2), a wound of the lung ; or (3), a wound of the liver or spleen through the diaphragm. Hæmorrhage from an intercostal or the internal mammary artery, though it may generally be known by the arterial blood escaping in jets, is sometimes difficult to distinguish from hæmorrhage from the lung. *Treatment.*—An intercostal artery should, if possible, be tied ; otherwise pressure-forceps may be left on, or the artery with the periosteum may be separated from the lower half of the rib and then tied, and to give room for this, a portion of the rib may be excised. Where assistance is not at hand, the centre of a sheet of lint (wrung out of an antiseptic solution) may be pushed into the pleural cavity and the hollow stuffed firmly with antiseptic wool. On drawing on the lint the artery will be compressed against the interior of the chest-wall, as shown in the accompanying diagram (Fig. 204). The internal mammary in the four upper spaces can be easily tied ; in the lower spaces a portion of the costal cartilage must be first cut away.

2. **Hæmoptysis** may be due to a bullet causing a minute external wound or to a stab, through which wound there may be some external hæmorrhage. Frothy blood pours out from the mouth in an alarming fashion, but if not quickly fatal, there is a good prospect of spontaneous cessation and recovery. When the

bleeding is from the lung the patient must be placed at perfect rest on the injured side, and should suck ice. Internally, lead and opium, gallic acid, turpentine, hamamelis, or ergot are given, but have no influence. Some recommend the closing of the external wound and the application of a bandage to the chest, so that the blood may collect in the pleura, press on the lung, and thus stop the bleeding. Others, again, have tried to stop the hæmorrhage by opening a vein and bleeding rapidly, so as to induce syncope and thrombosis of the bleeding vessel. Rest with as little fluid to drink as possible is the best method of treatment.

3. **Hæmothorax,** or hæmorrhage into the pleura, may occur either with or without an external wound. It is, perhaps, most often due to a fragment of a broken rib penetrating the lung or wounding an intercostal artery. The *signs* are those of internal hæmorrhage with rapidly extending dulness to percussion, absence of breathing sounds, bulging of the intercostal spaces, and increasing dyspnœa. It may be distinguished from pleurisy and pneumonia by coming on immediately after the injury, and by the absence of fever. *Treatment.* — Similar to that for hæmorrhage from a wounded lung. Should the breathing become dangerously embarrassed the blood must be drawn off with the aspirator. Should suppuration occur the chest must be opened and freely drained.

Fig. 204.—Method of compressing a wounded intercostal artery. A, Artery. L, Sheet of lint. R R, Ribs. W, Plug of antiseptic wool.

4. **Pneumothorax,** or air in the pleura, is generally the result of a wound of the lung by a fragment of a broken rib. It is attended with more or less collapse of the lung, and may be known by tympanitic resonance, absence of breathing sounds, or amphoric breathing, metallic tinkling, bulging of the intercostal spaces, and increasing dyspnœa. When combined with hæmothorax or with pleuritic effusion, the lower part of the chest will be dull to percussion, and a splashing sound on shaking the patient (*succussion*) may be heard on auscultation. The air is usually absorbed as soon as the wound of the lung heals, but should the breathing become seriously affected, it may be removed with the aspirator, or allowed to escape through a cannula left in the chest and protected by an antiseptic gauze dressing.

5. **Emphysema,** or air in the connective-tissue spaces, is sometimes called surgical emphysema to distinguish it from the medical affection of the same name in which the air cells of the lung are dilated. It is generally due to a crush causing a wound of the lung combined with a laceration of the parietal and visceral layers of the

pleura, and is a very frequent complication of fractured ribs. The air either escapes into the pleura at each inspiration, and thence during expiration is forced through the parietal layer into the subcutaneous connective tissue, or it passes, if there are adhesions between the two layers of the pleura, directly from the lung into the subcutaneous tissue. More rarely it is due to a rupture of the lung without injury of the pleura, the air then escaping at the root of the lung into the posterior mediastinum, and thence into the connective tissue of the neck and arms. More rarely still it may occur without a wound of the lung, or even without a wound of the pleura, *e.g.*, during labour. *Signs.*—The emphysema, though usually limited to the seat of injury, may extend somewhat widely around it, and in rare instances has spread over the whole body. It gives rise to an ill-defined flattened swelling unattended with signs of inflammation and unaltered on inspiration and expiration. On pressing on the swelling a peculiar crackling sensation is experienced, like that of rubbing the hair between the fingers. *Treatment.*—A pad and bandage is all that is usually necessary, but should the air instead of becoming absorbed extend so widely as to interfere with respiration, a puncture or two with a tenotome must be made to let it escape. Extensive suffusion of the face, and ecchymoses, especially of the conjunctiva, are due to the venous obstruction with asphyxia induced by the crush.

6. **Prolapse and hernia of the lung.**—*Prolapse* of the lung occasionally occurs through a wound in the chest-wall. It should be returned by gentle pressure, the wound being slightly enlarged if necessary, and then sutured to prevent a fresh protrusion. If the prolapsed portion has become adherent and congested it may be removed by the knife or ligature, taking care not to break down the adhesions of the visceral layer of the pleura to the chest-wall and so open the pleural cavity. If lacerated and bleeding, sutures should be inserted. *Hernia of the lung*, or *pneumocele*, is sometimes met with after a penetrating wound of the chest has cicatrised, or even when then there has been no wound of the skin, but rupture of an intercostal muscle and the underlying pleura. It has also resulted from trumpet-blowing. Its most common situation is in the fifth or sixth intercostal space, but it has been met with at the root of the neck after injury to the apex of the pleura. It forms a soft, crepitant, resonant, rounded swelling, which can be made smaller by pressure, and generally becomes more prominent on forced expiration or coughing. On listening over it a harsh vesicular murmur is heard. The *treatment* consists in protecting it with a properly-shaped pad or leather shield moulded to the part.

7. **Wound of the diaphragm and abdominal viscera.**—A wound on the right side of the chest may penetrate the liver through the diaphragm, and is known by the dark venous blood which wells up

as compared with the bright blood from the chest-wall and the bright frothy blood from the lung. The wound in the chest-wall, if not sufficient, may be enlarged, and a strip of iodoform gauze pushed through the diaphragm into the liver, afterwards being withdrawn a little on each day.

On the left side the left lobe of the liver may be similarly injured, or the spleen, from which the blood is less dark, or the stomach with extravasation of its contents, or a portion of omentum or intestine may prolapse. Hæmorrhage is arrested by plugging, a wound in the stomach sewn up, prolapsed omentum is ligatured and cut away. After washing away extravasated blood and stomach contents, the diaphragm may be sutured and a strip of gauze inserted into the pleura cavity, or the strip may be carried through the diaphragm into the lesser omental cavity.

For an account of such complications as *Pleurisy and Empyema*, *Hæmopericardium*, *Suppurative Pericarditis*, and *Mediastinal Abscess*, also for operations on the chest, see *Diseases of the Chest*.

INJURIES OF THE ABDOMEN.

Contusions of the abdominal wall, especially when due to a sharp or sudden blow or a severe crush, should always be regarded as serious, as they may be complicated by grave internal injuries. Thus, the peritoneum may be lacerated, one of the viscera ruptured, or a large blood-vessel injured and blood extravasated into the peritoneum or subperitoneal tissue; whilst among the minor complications may be mentioned rupture of the rectus or other muscle of the abdominal wall accompanied by blood-effusion (*hæmatoma*) and possibly followed by suppuration and abscess. Even where no injury to a viscus has been sustained, a contusion of the abdomen is nearly always attended with shock which may be severe, and in some instances has been fatal, probably from injury to the solar plexus. The *signs* of a simple contusion are pain, ecchymosis, tenderness and swelling, with a varying amount of shock. A ruptured rectus will be indicated by pain on putting the muscle into action, *i.e.*, by asking the patient to raise himself from the recumbent position without the use of his arms, and the presence of a gap and later of a swelling from the effusion of blood. The blood-tumour will be known by its sudden occurrence, and absence of signs of inflammation. *Treatment.*—The abdomen should be carefully examined, and any symptoms that may point to injury of a viscus carefully weighed. If the conclusion is come to that probably no serious injury has been sustained, the patient should still be treated cautiously, since it is impossible at first to say that such is not the case. Thus, he should be placed at absolute rest in bed, fomentations applied to the abdomen and hot

bottles to the extremities, and small doses of morphine given subcutaneously if there is much pain; whilst for precaution's sake for the first twelve or twenty-four hours nothing should be given by the mouth or only small quantities of iced milk. On the other hand, if the balance of evidence is in favour of some serious lesion being present, it is better to make an exploratory incision than to wait till peritonitis has been set up, when any interference will probably be too late. Where there is rupture of the rectus the parts should be approximated as much as possible by position. If a blood-tumour forms, cold should be applied, but it should on no account be opened unless suppuration occurs, as the blood will nearly always in time be absorbed.

Laceration of the peritoneum may occur from a blow or crush of the abdomen without injury of the viscera, and may be complicated when a large vessel has been ruptured by extravasation of blood into the peritoneal cavity or sub-peritoneal tissue. There are no special *signs* of this injury; but restlessness, a sensation of sinking, yawning, an anxious countenance, coldness and blanching of the surface when complicated by hæmorrhage, with an absence of vomiting and often of pain, are said to indicate it. Peritonitis nearly always quickly supervenes. *Treatment.* — Like that of peritonitis.

Suppuration and abscess may follow on any injury of the abdominal walls, extravasation of urine, etc.; or may be due to the breaking down of a blood-tumour, or to injury of the bones forming the walls of the abdomen or pelvis. The suppuration may be acute or chronic, superficial or deep. When deep it is very apt to be diffuse, and extend along the muscular planes or between the peritoneum and transversalis. When superficial, except as the result of extravasation of urine, it is generally circumscribed and often confined to the sheath of the rectus. *Signs.*—The acute form is attended with the general and local symptoms of inflammation, followed by those of suppuration, and subsequently, by the signs of an abscess. In the chronic form there will probably be no constitutional signs; but a localised swelling, either superficial or deep, will generally be present in which fluctuation may be detected. *Treatment.*—Early and free evacuation of the pus.

Rupture of the viscera.—The rupture of an abdominal viscus is always a most serious accident, and one which is frequently, though not invariably, fatal.

Cause.—Generally a severe crush of the abdomen, as between the buffers of railway cars; or a kick or blow, or the passage of a wheel over the abdomen.

Pathology.—Any of the viscera, including even the pancreas, may be ruptured; but the liver, intestines, kidneys, and bladder are those most frequently injured. In rupture of the *liver* or *spleen* severe hæmorrhage into the peritoneal cavity, followed by peritonitis,

ensues, unless the peritoneal covering escapes rupture, when no blood is extravasated. In rupture of the *stomach*, *gall-bladder*, or *intestines* their contents escape into the peritoneal cavity, setting up rapidly-fatal peritonitis, though in the case of the stomach and gall-bladder the more immediate danger is death from shock. Rupture of the intestine usually occurs where the duodenum joins the jejunum. The large intestine is rarely injured in consequence of its protected position. Rupture of the *kidney* is a less fatal accident, as the organ lies well behind the peritoneum; but when the crush is severe it may be attended with serious hæmorrhage or the organ may be completely pulped, the capsule torn, and the peritoneum involved. It is liable to be followed by perinephritic abscess, peritonitis, or cystitis from retained clots and nephritis of the opposite kidney from extension of the septic inflammation up the ureter. In rupture of the *ureter* urine is extravasated behind the peritoneum. For rupture of the bladder, see *Injuries of Pelvis*.

The *signs* of a ruptured viscus are often obscure, but great shock, extreme collapse, and intense localised pain, together with the history of a severe crush of the abdomen, point to such an injury having occurred. Beyond a surmise that one of the viscera has been injured, it may be quite impossible to localise the mischief. The following signs, however, may serve to indicate the probable nature of the lesion; thus—1. In rupture of the *liver* there may be pain in the right hypochondrium, perhaps a fracture of the ribs over the liver, symptoms of internal hæmorrhage, increase of the hepatic dulness in consequence of blood-extravasation, and later, peritonitis, jaundice, and very occasionally diabetes. When the rupture is slight, or the peritoneal covering is not torn, the injury may remain unsuspected and the patient recover. Or after a few days the peritoneal covering may give way and peritonitis ensue. 2. In rupture of the *spleen* the signs are similar, save that the pain is referred to the left side, and there may be increase of the splenic dulness, and perhaps fracture of the ribs in that region. 3. Rupture of the *stomach* is attended with extreme collapse, intense pain in the region of the stomach, free gas in the peritoneal cavity and hence loss of liver-dulness, and if not rapidly fatal, with vomiting of blood, followed by peritonitis. 4. In rupture of the *gall-bladder* there is pain in the region of the liver, followed by localised or general peritonitis, and, if the patient survive, by distension with fluid of the peritoneal cavity and great emaciation; on puncture, a bile-stained fluid is withdrawn. 5. In rupture of the *intestines*, in addition to the collapse and intense pain radiating over the abdomen, there may be pain on pressure, board-like hardness and rigidity of the abdominal parietes, absence of abdominal breathing, tympanites with loss of liver-dulness, vomiting, first of the contents of the stomach, then of bile, and perhaps of altered blood;

and later blood in the stools; increased tympanites with dulness in the flanks; and, still later, peritonitis. 6. When a *kidney* is ruptured there will probably be a history of a blow or other injury of the loin, increased frequency of micturition, blood in the urine, often in large quantities, severe pain increased on pressure over the kidney, signs of bruising in the lumbar region, increased dulness or distinct swelling in the region of the kidney, retraction of the testicle, and signs of internal hæmorrhage and marked shock when the laceration is severe; later there may be evidence of distension of the bladder with clots or urinary extravasation in the loin, pus in the urine, and signs of deep-seated suppuration (*perinephritic abscess*) or peritonitis, or symptoms of septic nephritis of the opposite kidney. 7. Rupture of the *ureter* may give rise to a fluctuating retroperitoneal swelling containing urine, and blood will probably appear in the urine in a few days.

Treatment.—Whatever the nature of the injury, if there are signs of severe *internal hæmorrhage* laparatomy should be done, and an attempt made to stop the bleeding. In rupture of the *liver* the abdomen should be opened, the rent in the liver sutured, or, if this is impossible, plugged with iodoform gauze, the end of the gauze being left as a drain in the laparotomy wound. In rupture of the *spleen* the immediate removal of the organ is probably the best way of preventing death from hæmorrhage. In both injuries stimulants for rousing the patient from his collapse should be carefully avoided before the hæmorrhage is arrested. In rupture of the *stomach* or *intestines* the abdomen should be opened, the rent sewn up by Lembert's sutures, and the peritoneal cavity thoroughly cleansed by irrigation with warm, weak boracic solution, or sterilised water. If the rent is not readily found, insufflation with air may reveal it. Subsequently the patient should be given morphine and atropin subcutaneously if there is much pain, and nothing whatever should be taken by the mouth for the first twelve to twenty-four hours. Nutrient enemata and stimulants, if the strength flags, should be administered. In rupture of the *kidney* the patient should be placed at perfect rest and given ergot, hazeline, or gallic acid to restrain hæmorrhage, the loin strapped or fomented if there is much pain, the bladder washed out if filled with clots by means of a lithotrity evacuator, or a median cystotomy may be performed. If the bleeding is severe an incision in the loin or nephrectomy may become necessary. The swelling following rupture of the *ureter* should be laid open and the ureter sutured as described under *Wounds of the Ureter* (p. 553). This failing, nephrectomy will be required.

Wounds of the abdomen may be divided into the *penetrating* and *non-penetrating*, according as they do or do not involve the peritoneal cavity. Whilst ascertaining this point, the strictest antiseptic precautions should be observed.

Non-penetrating wounds should be treated like wounds in other situations, especial care, however, being taken to establish a good drain, as should they extend deeply they are apt to be complicated by effusion of blood or suppuration in the sub-peritoneal tissue. They are liable to be followed by ventral hernia.

Penetrating wounds are such as involve the peritoneal cavity. They may be divided into the following:—1. Simple penetrating wounds without injury or protrusion of the viscera. 2. Penetrating wounds with injury, but without protrusion of the viscera. 3. Penetrating wounds with protrusion, but without injury of the viscera. 4. Penetrating wounds with both protrusion and injury of the viscera.

I. **Simple penetrating wounds without injury or protrusion of the viscera.**—When the wound is large there will usually be no difficulty in ascertaining the fact that the viscera have escaped injury. If, however, the wound is very small—a mere puncture, or made obliquely, it may be difficult or impossible to say whether any injury to the viscera has been done, or, indeed, whether the abdominal cavity has been penetrated. In such a case it was formerly taught that the wound should on no account be probed for the purpose of settling the point, but the patient treated as if the wound had penetrated but had not injured the viscera. If all antiseptic precautions are taken, however, it is safer to thoroughly explore the wound, by enlarging it if necessary, so as at once to ascertain whether it has penetrated the peritoneum, and whether the viscera have escaped injury, and not to wait till the diagnosis is settled by the onset of peritonitis. Where there are signs of internal hæmorrhage no surgeon should hesitate to search for the bleeding vessel. *Treatment.*—The wound should be covered with gauze, whilst the skin around is being rendered aseptic (see p. 181), then the wound if large should be thoroughly cleansed, and brought together by three rows of sutures, the peritoneum being first united with fine silk sutures, then the muscles and aponeurosis, and finally the skin (Fig. 75, p.189). In any case the patient should be placed at absolute rest in bed and fed by the rectum for the first few days, but nothing should be taken by the mouth for a day or two. Morphine and atropin may be given hypodermically if there is pain. Should peritonitis supervene it must be treated as described under that head.

II. **Penetrating wounds with injury, but without protrusion of the viscera.**—When the wound is large, and the injured viscus can be seen, the nature of the injury will probably be obvious. When, however, the wound is small, unless there be an escape externally of gas, fæces, bile, urine, or the contents of the stomach, there are no primary signs, with the exception perhaps of emphysema about the wound, absolutely diagnostic of a viscus having been injured. Intense pain and extreme collapse, if present, no doubt point to such an injury having probably occurred; but both

pain and shock are so variable as really to afford little guidance. Later the presence of free gas in the peritoneal cavity and the escape of blood from the anus would make it highly probable that the intestine had been wounded. In a doubtful case of wound of the intestine the rectum may be inflated with air by a Higginson's syringe. If the gut is wounded the air will escape through the rent into the peritoneum and thence through the external wound. In a doubtful wound of the stomach this viscus may be inflated by a tube passed through the mouth. The tympanites will be confined to the stomach if that viscus is sound, or spread to the rest of the abdomen and efface the liver-dulness if it is injured. Any of the viscera may be implicated; but wounds of the liver, gall-bladder, spleen, and stomach, are much less common than wounds of the intestine. The danger to be apprehended is hæmorrhage in the case of the liver or spleen, extravasation in the case of a hollow viscus, and in all, peritonitis. The amount of extravasation will depend upon the size of the wound, and whether the viscus was distended or empty at the time of injury; when the wound is a mere puncture, there may be none. If the extravasation is but slight, or escapes externally through the wound in the parietes, it may be cut off from the general peritoneal cavity by a local peritonitis, and the patient recover. An extensive extravasation is nearly always followed by diffuse septic peritonitis, which, unless surgical measures are undertaken, will certainly prove fatal in a few days.

III. **Penetrating wounds with protrusion but without injury of the viscera.**—The protruding viscus is nearly always a portion of intestine or omentum. It should be cleansed with some weak antiseptic lotion, and returned by gentle uniform pressure into the abdomen, care being taken not to force it between the peritoneum and fascia transversalis. If the wound of the parietes is too small to allow the viscus to be returned easily, it should be cautiously enlarged. If the portion of intestine is congested or inflamed, it may still be replaced. If gangrenous, however, it should on no account be returned, but the gangrenous portion excised and the continuity of the gut restored by one of the methods to be presently described, and then replaced in the abdomen. In exceptional cases, as where the patient is suffering from excessive shock and is almost moribund, it may be left *in situ*, an incision made into it and a Paul's tube tied in. An artificial anus is thus formed, which can be closed when the patient can undergo the operation. A congested portion of *omentum* should be transfixed and ligatured with thick silk so as not to cut through the thin-walled vessels, the congested portion removed, leaving a sufficient frill to prevent the ligature slipping and the stump returned. A gangrenous portion should be cut off and the stump, which is probably already adherent, separated from the parietes, ligatured at a healthy spot, the diseased part cut away, and the

stump returned. Great care should be taken if the wound is of a punctured character to ensure the closure of its deeper parts lest a hernia subsequently occur. The danger of this is well illustrated in Fig. 205. Thus, if necessary, the wound should be sufficiently enlarged to permit of the peritoneum being accurately united by a row of sutures, the muscles and aponeurosis and finally the skin being then united as in Fig. 75. The general treatment should be the same as that before described.

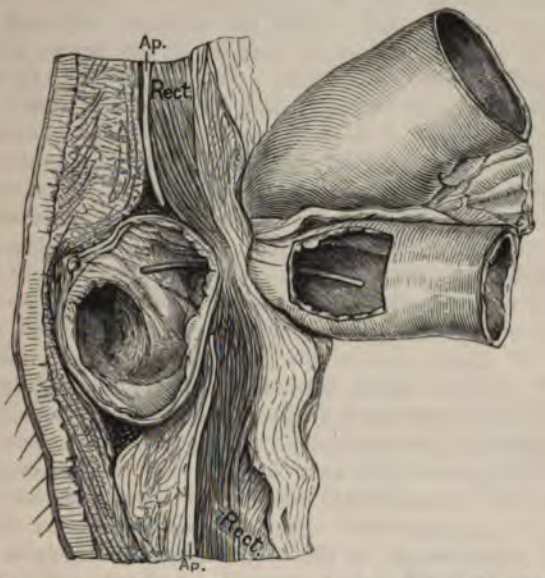


Fig. 205.—Traumatic hernia following a punctured wound of the abdomen. The wound healed by first intention, but four days after the injury a hernia appeared at its site and was reduced, but the reduction was incomplete, the gut having passed between the skin and sheath of the rectus and remained nipped at the opening through the sheath of the rectus; Ap., Aponeurosis; Rect., rectus muscle. (St. Bartholomew's Hospital Museum, No. 2158 *a*.)

IV. **Penetrating wounds with both protrusion and injury of the viscera.**—The protruded viscus is nearly always a portion of the small intestine, or a small knuckle of omentum. The wound in the intestine or stomach should be united by suture in the way described at p. 533, and the viscus then replaced. If the intestine is completely divided it may be united by one of the methods to be presently described, and returned; or an artificial anus, under some circumstances, may be made. If the wound is high up the intestine the former procedure should be the one always adopted, as if an artificial anus high up is made the patient will die of inanition.

Gunshot wounds of the abdomen.—In former days surgeons did not as a rule interfere with gunshot injuries of the abdomen unless there were some clear indications, such as signs of extravasation of blood or visceral contents, or a relatively large wound with prolapse. Some few patients recovered after more or less disturbance, but the vast majority of cases in which the bullet had really perforated the peritoneal cavity died. In view of this, and with the improvements in abdominal surgery, the experience gained from the number of pistol bullet wounds seen in civil practice, especially in the United States, has led to the general adoption of operative measures as soon as possible after the accident, first with a view to exploration and discovery of the extent of the injury, and then to repair that injury when found. This being done before septic peritonitis has occurred to any great extent, it is followed by success. In the vast majority of cases lesions, especially of the intestines, by pistol bullets, are found which could not possibly heal spontaneously. The large musket bullet of low velocity used in the warfare of the previous centuries, if it penetrated the abdomen practically always set up fatal injuries, the patients at most lingering a few days with septic peritonitis, and but exceptionally surviving owing to the formation of a fistula. The medical conditions in previous wars excluded any possibility of successful surgery. With the introduction of small rifle bullets of high velocity in recent wars, especially in South Africa, it has been found that much less damage is done to the abdominal contents. Many of the wounded of course died immediately, or very quickly from shock and hæmorrhage; by no possibility could they have been saved. Others died within a few days, but a remarkable number recovered with hardly any or no marked symptoms of the injury. In spite, however, of the extraordinary improvements in the conditions under which surgery was carried on in South Africa as well as in other recent wars, it cannot be said that any approach as a rule to the favourable conditions now recognised as essential in civil practice could be made. It was not generally possible to operate under sufficiently favourable conditions in the field, and the transport of patients to a base hospital, where the appliances regarded as necessary in civil practice were ready, was rarely possible in time or could be borne by the patient. Hence expectant treatment became the rule.

These perforating wounds of the abdomen caused by the new rifle bullets, when not immediately fatal from hæmorrhage or shock, were under expectant treatment followed by recovery in more than 60 per cent. of the wounded brought in by the ambulances. To explain the absence of septic peritonitis two suggestions offer themselves. Sir F. Treves, operating at an early date in the war, found the abdominal contents shortly after the injury already stuck together by aseptic fibrinous exudations without extravasation of intestinal contents. Mr. Bowlby concludes that in the cases of

recovery after the bullet had traversed the abdominal cavity the small intestines escaped injury. "As far as we are aware," he says, "the actual proof afforded by the demonstration of a wounded small intestine which has healed is wanting."

Nevertheless, in a few cases, where there was evidence of intraperitoneal hæmorrhage and the surgical conditions were favourable, an immediate operation for the arrest of hæmorrhage has been fully justified, both by the injuries discovered and the subsequent recovery; whilst among those under expectant treatment, some died after a few days from secondary hæmorrhage or localised abscess, or were with difficulty saved by a secondary operation. Hence, subject to future correction, it may be laid down:—

1. That in all cases of pistol bullet wounds, occurring in civil practice, which can be operated upon forthwith under favourable circumstances, *the wound should be immediately explored*, and being found to have penetrated the peritoneal cavity the examination should be continued, when extensive perforation of the intestines with more or less extravasation of contents, hæmorrhage, etc., will in the greater number of patients be discovered.

2. That in all perforating wounds by small rifle bullets of high velocity where no symptoms of a marked character are present, an expectant treatment may be adopted whenever surgical conditions are unfavourable for operation.

3. That signs of intraperitoneal hæmorrhage, or septic peritonitis appearing, the only chance for the patient is an operation.

4. Wounds by bullets of older pattern, sporting bullets, lacerations, and contusions from shells, etc., are of a very fatal character, in which likewise the only chance for the survival of the patient is an immediate laparotomy.

5. In cases presenting any features of doubt, even when the wound has been made by a small rifle bullet of high velocity, granted that the surgical conditions for operating and for the after-treatment of the patient are favourable, an immediate operation is a safer procedure than the expectant treatment.

As for the course of the bullet between the points of entry and exit, no particular direction is specially harmful or the reverse, for even if the exact position of the patient at the moment be ascertainable, the same cannot be said of his intestinal coils. If the bullet be retained, it is easily shown by the *x* rays, but its exact position is more difficult to locate, and the locating may take too much time for an acute case, although useful for a chronic one (see *Foreign Bodies in the Abdominal Cavity*, p. 549).

Treatment of abdominal injuries.

Expectant treatment is entirely one of rest, both of the body generally and of the abdominal contents. Hence transportation

after the accident may not be called for. A patient may be treated expectantly at his home, or near the field of battle, instead of being moved to a civil hospital, or transported to the base. Besides the careful nursing to avoid movement, there is the feeding by rectum, or very cautiously by the mouth, the judicious use of morphine and atropin subcutaneously, and the administration of enemata to prevent tympanites.

Operative treatment.—The first necessity may be the relief of shock by wrapping up the patients in hot blankets and giving brandy (℥ss. to ℥j.) per rectum with a nutrient or large saline enema. Or subcutaneous or intravenous saline infusion may be required in severe cases with hæmorrhage, after the bleeding point has been controlled. Strychnine injections (dose, $\frac{1}{60}$ gr.) may be exhibited at intervals during the operation, but the total administered should not exceed $\frac{1}{10}$ gr. Sometimes the stomach may be washed out, and this is especially the case when the patient is vomiting fæcal material.

A further preliminary is the thorough cleansing of the skin of the abdomen. Ether should be the main anæsthetic; if chloroform be used, it is necessary to have some ether at hand should the patient faint. 1. First the wound in the abdominal wall is wiped out with a strong antiseptic, and explored to ensure that it has penetrated. 2. Penetration being confirmed, the wound in the parietes is enlarged so as to give room for thorough examination of the abdominal cavity. The apparent region of the injury is in the first place shut off from the uninjured remainder by sponges or gauze pads. Next the patient is put into a suitable position, and then the injured viscus is examined, and, if possible, *e.g.*, the stomach or intestine, it is drawn forwards for better inspection. If there is difficulty in finding punctured wounds of the intestine or stomach caused by a bullet, air may be pumped in by means of a Higginson's syringe through a long rectal tube, or by a tube passed into the stomach. But the only trustworthy method is to pass the gut through the fingers upwards and downwards. The stomach or intestine being found wounded, sutures are applied or Murphy's button used as described below.

Methods of uniting wounded intestines:—

1. Bag suture for punctures and small circular wounds.
2. Linear suture for linear wounds.
3. Circular enterorrhaphy and end-to-end union by Murphy's button.
4. Lateral anastomosis.
5. Lateral implantation.

Having drawn forwards the wounded bowel and protected the peritoneal cavity from contamination, fæcal contents may be squeezed out, especially from the proximal end, and then further escape of contents prevented. This may be done (*a*) by the assistant lightly compressing the intestine above and below the wound with the finger and thumb of each hand; (*b*) by lightly

compressing the bowel with a drainage-tube passed through the mesentery, drawn just tight enough and fixed by a clamp; (*c*) by a large safety-pin, the point of which is passed through the mesentery under the bowel, a bit of sponge is placed over the bowel, then the pin is clasped, and thus the bowel is compressed by the sponge, or (*d*) by special intestinal clamps (*e.g.*, those by Mr. Makins).

Union of the intestine.—The peritoneum and muscular coat unite readily; the mucous coat can only unite to itself or to the other coats by its submucous aspects. But when divided there is a great tendency for the cut edge of the mucous membrane to curl outwards; hence it is a *sine quâ non* whatever method of uniting is adopted that the mucous membrane should be turned inwards towards the cavity of the viscus. No particle of the mucous surface must intervene between the superficial coats nor any track of a

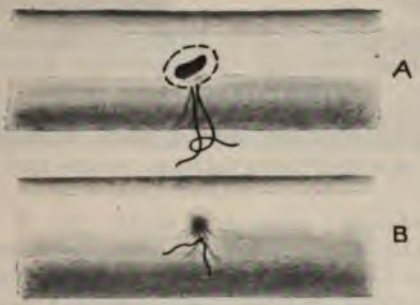


FIG. 206.—Bag suture for closing punctures and small circular bullet wounds. A, the suture inserted; B, the suture drawn tight and tied.

suture cause a communication between the mucous and peritoneal surface. The strongest part of the intestinal wall, the tissue which most firmly holds sutures, especially when any inflammation is present, is the submucous connective tissue (the basis of catgut). Hence the necessity, in order to resist tension, of including this layer in the suture.

1. **The bag suture.**—A fine sewing needle with silk is passed in and out of the seromuscular coat round the hole (Fig. 206, A), to be closed. The suture is gently drawn up and tied whilst the edges of the wound are pushed inwards so that the mucous coat in particular is well invaginated, whilst on the surface of the peritoneum (Fig. 206, B) a circular pucker is alone visible.

2. **The linear suture.**—A linear wound may be united by a seromuscular or Lembert's suture, *i.e.*, a suture inserted through the serous and muscular coat only (Figs. 207, 208), not puncturing anywhere the mucous coat, so that septic material cannot escape along the line of suture to infect the wound. When the sutures are tied the mucous membrane is turned inwards towards the

lumen. Lembert's suture may be applied as interr
as continuous sutures; in the latter case every fourth s
be passed through the loop as in the button-hole suture,
prevent yielding. Halsted's square or mattress sutu
through the serous and muscular coat, and takes up
the firm submucous fibres, especially whenever there is

Fig. 207.—Section of intestine united by Lembert's sero-muscular suture.

Fig. 208.—Intestine show
insertion. Lembert's s
cular suture.

ensure a better hold. They may be passed as interrupt
(see Fig. 209), or a continuous mattress suture may be
the same way.

The *Czerny-Lembert suture* is a double row of sutu
suture (Fig. 210) must include at least the mucous
and submucous tissue, and may generally with advanta
also the muscular coat and edge of peritoneum. Above thi

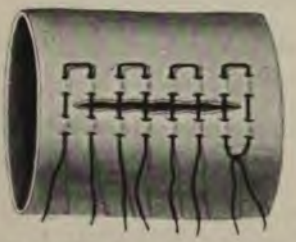


Fig. 209.—Intestine with Halsted's sutures applied.

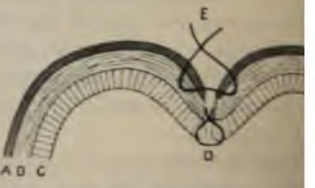
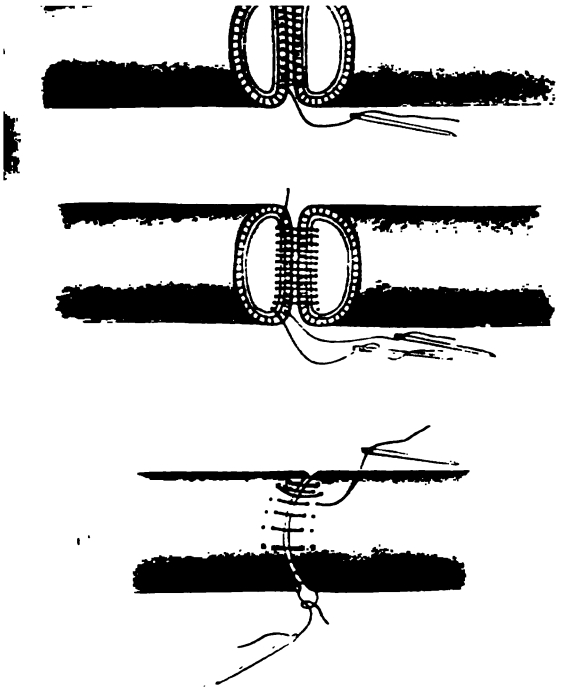


Fig. 210.—Czerny-Lembert sutur
toneal; B. Muscular; and C. M
D. Mucous stitch. E. Lembert

a seromuscular or Lembert's suture, which on being tight
inwards the deep row. The mucous membrane must not
in the latter, since if this were done there would be
peritonitis from leakage along the thread. The superfic
should be introduced about two lines from the edge of
and brought out at the margin of the serous coat,
passed in the same manner on the opposite side (Figs.



.—Circular enterorrhaphy by the Czerny-Lembert method, using a continuous
. A. The posterior half of the seromuscular suture first inserted. B. The
or half of the deep suture penetrating the mucous coat also inserted.
e completed anterior half of the deep suture is being drawn up and tied to
e end at the starting point; the anterior half of the seromuscular suture

lumen. Lembert's suture may be applied as interrupted, or as continuous sutures; in the latter case every fourth stitch may be passed through the loop as in the button-hole suture, so as to prevent yielding. Halsted's square or mattress suture passes through the serous and muscular coat, and takes up a little of the firm submucous fibres, especially whenever there is tension, to

FIG. 207.—Section of intestine united by Lembert's seromuscular suture.

FIG. 208.—Intestine showing the insertion. Lembert's seromuscular suture.

ensure a better hold. They may be passed as interrupted sutures (see Fig. 209), or a continuous mattress suture may be inserted in the same way.

The *Czerny-Lembert suture* is a double row of sutures. The suture (Fig. 210) must include at least the mucous membrane and submucous tissue, and may generally with advantage include also the muscular coat and edge of peritoneum. Above this is inserted

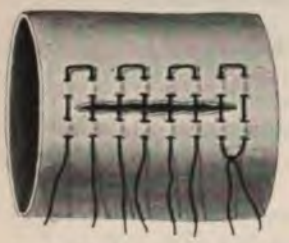


FIG. 209.—Intestine with Halsted's sutures applied.

FIG. 210.—Czerny-Lembert suture. A. Peritoneal; B. Muscular; and C. Mucous coats. D. Mucous stitch. E. Lembert stitch.

a seromuscular or Lembert's suture, which on being tightened turns inwards the deep row. The mucous membrane must not be included in the latter, since if this were done there would be danger of peritonitis from leakage along the thread. The superficialsutures should be introduced about two lines from the edge of the wound and brought out at the margin of the serous coat, and then passed in the same manner on the opposite side (Figs. 208, 209).

If, however, the edges are lacerated the sutures should be introduced further from the wound, and brought out a good line from the margin, so as not to include the bruised tissues. Sufficient sutures should be passed to ensure the parts being everywhere in apposition, and should not be tied too tightly, lest gangrene, the commonest cause of non-union, ensue. One or more

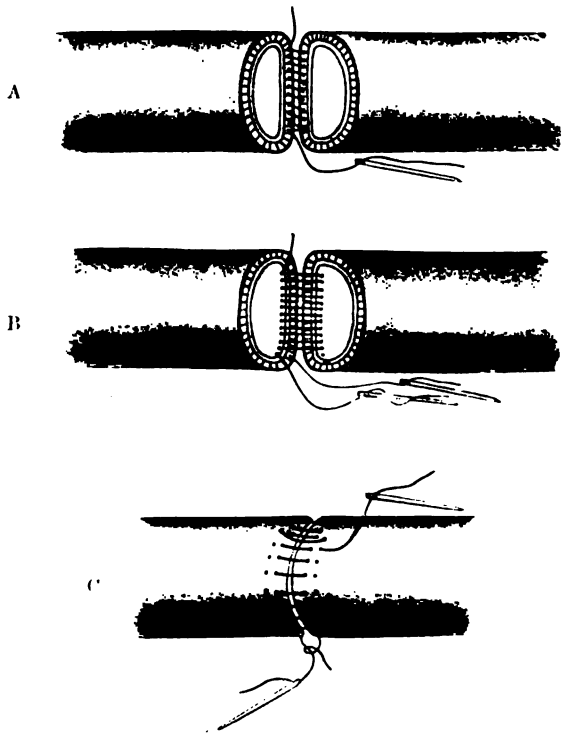


FIG. 211.—Circular enterorrhaphy by the Czerny-Lembert method, using a continuous suture. A. The posterior half of the seromuscular suture first inserted. B. The posterior half of the deep suture penetrating the mucous coat also inserted. C. The completed anterior half of the deep suture is being drawn up and tied to the free end at the starting point; the anterior half of the seromuscular suture is in course of being inserted.

stitches should be inserted beyond each end of the wound so as to ensure complete closure at these spots. The peritoneal surfaces thus placed in contact unite by adhesive inflammation. The sutures either remain encysted, or ulcerate through the mucous membrane, and drop into the interior of the bowel. It is not safe to suture a wound—(1) when the wound runs longitudinally along the mesenteric aspect, inasmuch as gangrene of the part cut off from its vascular

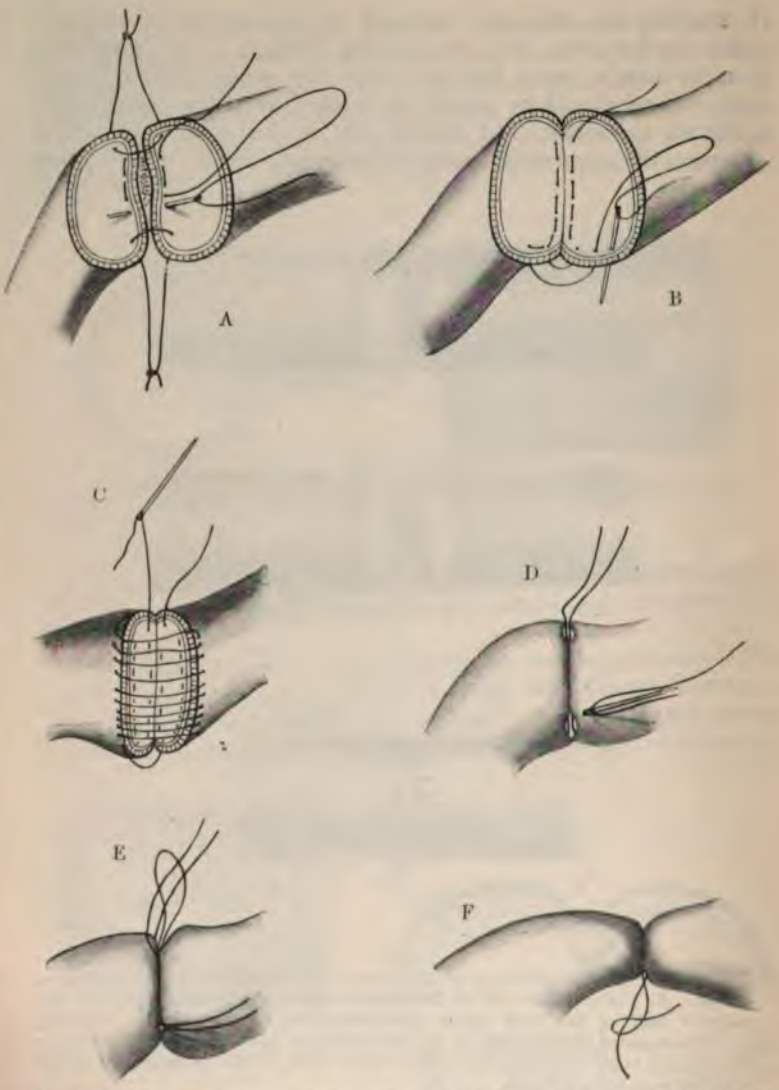


FIG. 212.—Connell's suture. A shows the ends of the gut approximated and held by a temporary fixation suture on either side of the mesenteric attachment. The suture is passed in and out from the mucous surface, commencing at the mesenteric attachment, and this running suture may be fixed at any point by making a back stitch. B shows the suture continuing to be inserted round the bowel opposite to the mesenteric attachment. C shows the suture inserted all round to the starting point, and about to be drawn up. All the sutures having been inserted from the mucous surface, the tightening will invert the edges. In order to get the knot inside a special procedure is adopted. D shows a threaded needle held with its eye forwards, which is passed into the lumen between the sutures opposite to the

supply will inevitably ensue; (2) when suturing would reduce the lumen of the gut to less than half its normal size; (3) when there is much bruising of the gut; (4) when there are several wounds close together. In such cases the injured portion of the intestine should be excised and the two ends united by some form of circular enterorrhaphy, or a lateral anastomosis may be formed.

3. **Circular enterorrhaphy** is the uniting of the ends of the completely divided intestine with the peritoneal surfaces in contact by a row of sutures around the circumference of the bowel. For this purpose various methods are employed. Simple suture is done with fine round sewing-needles, straight or curved, threaded with silk. The needles have split eyes, and so can be easily threaded. When continuous sutures are employed only two or three needles are needed; if interrupted, a number must be threaded before the operation and laid in order, or there will be delay. In place of sutures Murphy's button may be employed, and is by far the best method, when the patient's condition is desperate and speed the chief element for success.

Fig. 213.—To show the ridge on the inner wall of the gut after circular enterorrhaphy by the Czerny-Lembert suture. This ridge may much diminish the calibre of the tube. (St. Bartholomew's Hospital Museum, No. 2040 *p*.)

(*a*) A single or double row of *Lembert's suture*, similar to that described for a linear wound, but going round the bowel to the starting point. A single row of seromuscular sutures will bear but very little tension, so that it is only used when great speed is necessary in finishing the operation, but under such conditions Murphy's button had better be employed. A double row, the second invaginating the first, is stronger, and has the advantage of turning inwards the mucous membrane without sutures coming near its septic surface. There are two objections: first, that as the sutures

mesentery, and then across the lumen, and protruded at the same aperture with the free ends. E. The withdrawal and unthreading of this needle leaves a loop, by means of which the free ends of the inserted suture are drawn, F, out of the bowel and tied in a knot. This procedure puckers the bowel for the moment, the mesenteric attachment being drawn up towards the opposite point. But on pulling on the puckered bowel the knot slips inside, and nothing is to be seen externally but the inverted edge of peritoneum on each end of gut held in firm apposition.

do not pass through the strong submucous coat the line of union does not bear tension well, and secondly, the mucous membrane is not held pressed together, therefore blood may ooze from it freely.

(*b*) *The Czerny-Lembert suture.*—This is a double row of sutures applied generally by the continuous method, looping about every

Fig. 214.—Mayo Robson's method of uniting divided intestine; application of serous stitch to distal half of gut before beginning the mucous stitch; the bobbin not yet inserted.

fourth stitch, as in the button-hole suture (Fig. 70, p. 187), so as to fix it. The deep sutures go through all the coats; by including the mucous membrane the edges are pressed together and oozing stopped, and by passing through the submucous coat the suture is rendered very strong (Fig. 217). Above this is inserted a row of Lembert's

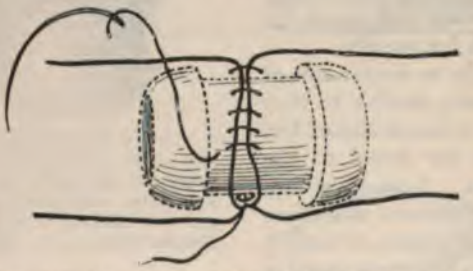


Fig. 215.—Mayo Robson's method of uniting divided intestine; the bobbin *in situ*; the mucous stitch nearly completed.

sutures, turning in the deeper row, and so preventing leakage from the mucous on to the serous surface along a suture tract. It may be said of this suturing method that it can be adapted to any operation, and that by practice, commencing on intestines in the post-mortem room, and using the continuous suture, the operation is fairly quickly accomplished. Care must be taken to close the mesenteric attachment where the peritoneal layers separate to enclose the gut, and where therefore the suture may miss the muscular coat. Here an extra interrupted suture may be put in, or the gap in the mesentery

may be drawn firmly together by a return stitch or bootlace suture.

(*c*) *Connell's suture* (Fig. 212) is a single continuous in and out glover's suture through all the coats, by which the edges of the gut are turned inwards, so that all sutures are buried within the peritoneal fold.

It has been objected that by the above method a marked ridge is formed, which narrows the lumen of the bowel (see Fig. 213), but this results from taking up too much of the edge of the gut in the sutures.

(*d*) Mr. Mayo Robson has modified the circular suture as follows:—He first passes a square or mattress continuous Lembert's suture round the half circle furthest from the surgeon, but for the moment leaves it loose (see Fig. 214). Then he inserts the deep suture through all the coats round the same further semicircle, lays in the lumen a hollow decalcified bone bobbin, completes the rest of the circle, first with the deep suture (see Fig. 215) over the bobbin, and then with the superficial suture with which he began, he finishes the circle, draws the suture tight over the bobbin and knots the ends. Mr. Allingham's bobbin is shaped rather like a dice-box; others have employed a ring of rubber tubing, or even a hollow cylinder cut out of a raw potato or turnip.

Fig. 216.—Portion of intestine with line of suture covered by omental graft. I. Intestine. M. Mesentery. O. Graft. S. Suture fixing graft.

To strengthen the line of union a strip of omentum may be stitched over the line of suture (see Fig. 216).

(*e*) *Invagination methods*, as suggested by an intussusception. It is necessary as a preliminary to distinguish the proximal from the distal end of the bowel by passing the gut through the thumb and fingers upwards to the duodeno-jejunal junction, or downwards to the ileocæcal valve, so that it may be quite certain that the proximal is being invaginated into the distal end, and not the reverse, which has proved disastrous. *Maunsell's technique* is the more commonly employed.

Maunsell's method.—Bring the two ends of the divided bowel together by two temporary sutures passed through all the coats, one suture at the mesenteric attachment, the other opposite. The mesenteric suture should close the little triangle where the mesentery is reflected from the gut. Leave the long ends of the sutures intact. Pass them down the lumen of the distal portion of the bowel, and out through a longitudinal slit previously made in its wall opposite the mesentery, and about an inch from its cut end (Fig. 217). Draw on the sutures, and the proximal end o

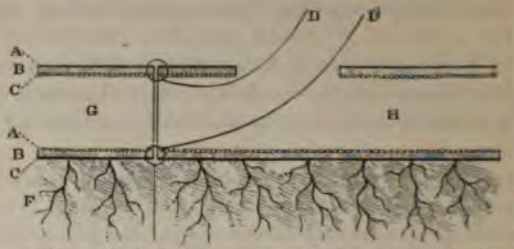


FIG. 217.—Maunsell's method of circular enterorrhaphy. A B C. Peritoneal and mucous coats. F. Mesentery. D D. Temporary sutures uniting pr distal portions of divided intestine, and passed out through longitudina in the distal segment of the intestine.

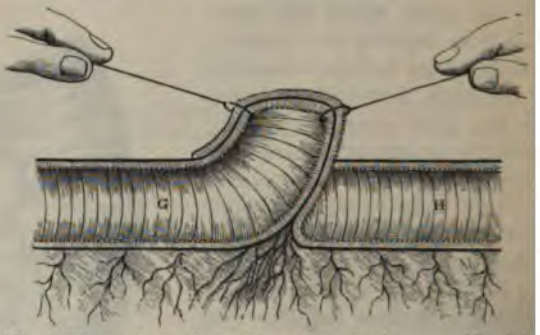


FIG. 218.—Maunsell's method of circular enterorrhaphy. G. The inte proximal portion. H. The interior of the distal portion of the bowel.

FIG. 219.—Maunsell's method of circular enterorrhaphy. G. The proxi H. The distal portion of the intestine. A. The needle in transit.

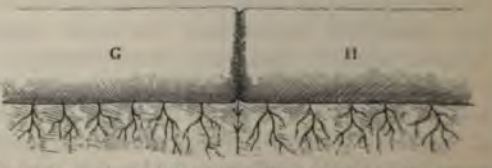


FIG. 220.—Maunsell's method of circular enterorrhaphy. Appearance at completion of operation. G. Proximal portion. H. Distal portion

(Fig. 218) will be invaginated into the distal end H, and thence pulled out of the longitudinal incision in the wall of the distal portion H. From Fig. 218 it will be seen that the serous surface of the two portions are in accurate apposition all round. Whilst an assistant holds up the intestine by the temporary sutures, drawing them gently apart, so as to render the lumen of the invagination an oval slit, pass a straight needle armed with fine silk across the slit a quarter of an inch from the cut ends through the whole thickness of the four walls of the intestine (Fig. 219). Hook up the suture, divide it and tie each half. In this way twenty sutures can be passed in ten transits of the needle. When sufficient sutures have been applied, cut short the temporary sutures and reduce the invagination by traction on the two portions of the gut and close the longitudinal slit by a continuous Lembert suture. On the completion of the operation the peritoneal surfaces are accurately in contact, and the knots are all inside (Fig. 220). The chief objection to the method is the infliction of the longitudinal wound.

FIG. 222.—Method of applying "puckering thread" (*b*) preparatory to inserting the button. At *a* the method of applying the return stitch so as to close the triangular interval (*c*) at the reflection of the mesentery is shown.

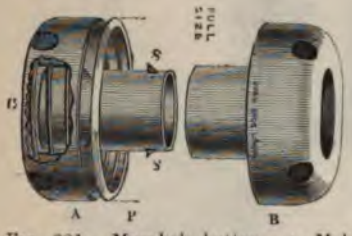


FIG. 221.—Murphy's button. A. Male half. B. Female half. P. Spring flange. *s s*. Springs projecting through openings in hollow stem. Part of the cap of the male half has been cut away at *c* to show circular spring which acts on flange. The round holes in the caps are for drainage.

(*f*) *Uniting by the use of Murphy's button.*—The only mechanical means which rivals the suture is the button invented by Dr. Murphy—the button of the best make and of the original design. Its great merit is the speed with which, after practice, the operation can be carried through. The objection raised to its use is that of leakage beside the button, the defenders of the

FIG. 223.—Murphy's button *in situ* from a patient who died twelve hours after an enterectomy. (St. Bartholomew's Hospital Museum, No. 2040 *q*.)

FIG. 224.—Longitudinal section through a Murphy's button and a piece of gut, the free ends of which had been joined by means of the button after an enterectomy. The section has been made to show the mechanism of the button. The specimen was taken from a woman who died soon after the operation performed for strangulated femoral hernia. (St. Bartholomew's Hospital Museum, No. 2040 q^1.)

FIG. 225.—Murphy's method of end to end approximation of divided intestine. The male and female halves of the button are secured in the ends of the divided gut by the "puckering threads," and ready to be pressed the one into the other.

button maintaining that this arises from lack of skill in its application. The other objection is the occasional retention of the button, requiring a further operation to remove it after its position has been localised by *x* rays. If not too big a button is used, it nearly always passes in time and without causing any trouble. One of us (Walsham) has the highest praise for it.

By this contrivance an end to end approximation or a lateral anastomosis may be quickly accomplished without sutures. The button consists (Fig. 221) of two halves. The male half A has

Fig. 226.

Fig. 227.

Figs. 226 and 227.—Showing method of holding male half and female half of button for insertion.

a spring flange F for keeping up pressure on the approximated intestine. The two springs, *s s*, projecting through openings in the hollow stem, act as the male thread of a screw when the shank is telescoped within the stem of the female half B. The intestine having been clamped, as previously described, pass the running thread (Fig. 222) by the overhand stitch (*b*) round the cut end of the intestine, beginning and ending opposite the mesenteric attachment. One return stitch (*a*) should be taken at the mesenteric attachment to close the triangular interval (*c*) which exists at the reflection of the mesentery from the gut. Insert one half of the button in the end thus prepared, tighten the running

thread so that the intestine is puckered up round the stem of the button, tie the ends of the thread and cut them short. Secure the other half of the button in a like manner in the other end of the intestine (Fig. 225). The method of holding the button during insertion

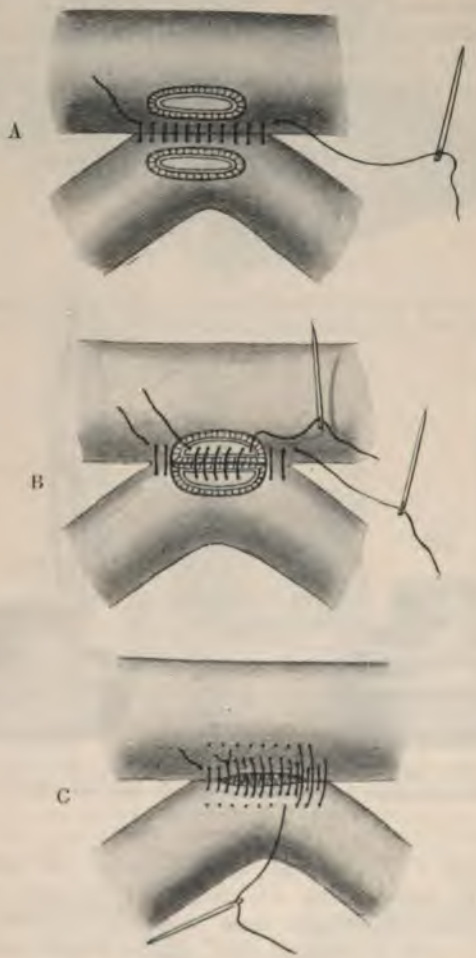


FIG. 228.—Lateral anastomosis by continuous Czerny-Lembert suture. A. The two tubes are placed in apposition, and the posterior half of the seromuscular or outer suture is first inserted. B. The two tubes are opened by a longitudinal incision, and the posterior half of the deep suture through all the coats is then passed. C shows the anterior half of the deep sutures drawn up and tied to its free end, whilst the anterior half of the seromuscular row is in course of being inserted. Dots show the other points where the needle has yet to be inserted, and the free end of the suture is ready for tying to the threaded end when the point from which the insertion of stitches commenced in A is again reached.

is shown in Figs. 226 and 227. Press the two halves together, and the peritoneal surfaces are held in close and accurate contact. The appearance of the part after the operation is complete is well shown in Figs. 223 and 224. To prevent leakage it is essential that the whole of the mucous membrane should be inverted before the approximation is made, and great care should be exercised in correctly passing the over-stitch on the mesenteric attachment, lest the peritoneum escape the grip of the button. The patient's motions should be watched for the button; sometimes it is retained for a day or two in the rectum.

4. **Lateral anastomosis** is especially indicated when the tubes to be united are of unequal size, especially when the upper is much larger than the lower. This operation consists in applying two portions of the intestine to one another, side by side, and fixing them in

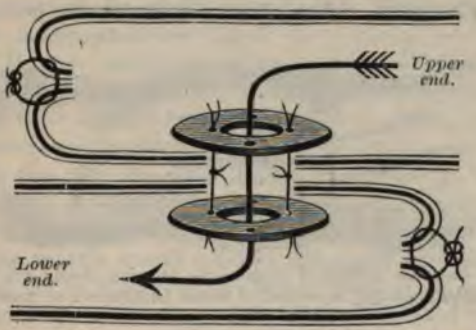


FIG. 229.—Diagram of intestine united by Senn's plates. The arrow shows the way in which the contents of the bowel pass through the plates and incisions in the wall of the bowel from the proximal into the distal portion. The cut ends of the gut have been invaginated and closed by a bag suture through the seromuscular coat.

this position, having first made a communication between them. The operation imitates the fistulous communications made by ulcerations between two mucous surfaces, or by the coalescence of two wounds. If a piece of bowel has been resected the two ends are first closed. This is most quickly done by a bag suture passed in and out of the seromuscular coat round the lumen, which is then tightened up and tied like the neck of a bag (Fig. 229), whilst the mucous membrane is invaginated. Then the two blind ends are placed in contact (see Fig. 228) by their surfaces opposite to the mesentery and fixed by a continuous seromuscular suture, which will form the half circle of the outer suture furthest from the surgeon. Then a longitudinal cut is made into each bowel and the deep suture inserted through all the coats so as to form a strong inner ring of suture round the communicating opening. Finally the outer seromuscular suture is completed in the half circle nearest the surgeon, and tied to the free end where the suture originally started.

Instead of continuous sutures, Halsted's sutures (Fig. 209, p. 534) may be used.

Many surgeons always use Murphy's button for lateral anastomosis. Fig. 230 shows the method of inserting the running thread to secure the button.

Senn's bone plates (Fig. 229) seem to have fallen into disuse.

5. **Lateral implantation.**—This is most usefully employed when the tubes to be united are of unequal diameter, especially when the upper is smaller than the lower, as when it is required to join the small intestines to the large. To do so the commencement of the lower bowel is closed as in the former case, whilst that of the upper remaining open is inserted into the lower bowel through a longitudinal slit opposite the mesenteric attachment. The implanted bowel can be fixed by a single or double ring of Lembert's sutures, by a ring of Halsted's square sutures, or by using Murphy's button. Fig. 232, showing implantation of the ureter, illustrates the principle.

FIG. 230.—To show the method of passing the running thread for fixing the half-button in Murphy's method of lateral anastomosis of intestine.

An *artificial anus* should very rarely be made in preference to union, for if at all high up the patient will surely die of inanition. When there is extensive damage to the large intestine and the patient is very weak, it may be proper to tie a Paul's tube into each end (see *Abdominal section*) and to close the opening later.

Destruction of the wall of the stomach by corrosive fluids.—It is extraordinary that fluids such as the mineral acids may be swallowed and appear to do little damage until the stomach, and even the pyloric end of the stomach, is reached. There rapid destruction and perforation may follow, or extensive ulceration and cicatrisation lead to pyloric stenosis, hour-glass stomach, etc. If the symptoms do not subside under rest and medical treatment, operative procedures are necessary, such as gastro-jejunostomy, division of strictures or gastroplasty, or excision (see *Diseases of Stomach*).

Wounds of the stomach in civil life are generally occasioned by stabs or pistol shots aimed at the heart, but are occasionally met with in lacerated wounds of the abdominal wall as through goring by a bull. If the large vessels behind the stomach are injured the accident is fatal; if they escape, life may be saved by an immediate operation. A stab aimed at the heart may traverse

the lower part of the left pleural cavity and reach the stomach through the diaphragm. Wounds in war from rifle bullets, shells, or bayonet-stabs are usually fatal from hæmorrhage. If the stomach is full at the time of injury, the stomach-wound may prolapse and become fixed in the abdominal wound so that the contents escape externally; if nearly empty the contents escape into the peritoneal cavity, through which they may either become extravasated or remain confined above the colon. The diagnosis is evident when the stomach is prolapsed into the external abdominal wound. The escape of acid gastric juice and undigested food, whether externally, or into the peritoneal cavity, or into the pleura is conclusive. If further evidence is needed, it may be obtained by passing an œsophageal tube and inflating the stomach with air or coloured water.

Treatment.—The wound in the parietes should at once be enlarged if necessary, the wound in the gastric wall sought for, the edges invaginated and closed by a double row of Lembert's sutures. If the wound be quite recent, all the extravasation should be wiped out and the abdominal wound closed. If there is already some local peritonitis, a strip of gauze is left in. If there is general peritonitis, the peritoneal cavity must be thoroughly purified in the way described under *Peritonitis* (p. 551). If the injury has been inflicted through a trans-thoracic wound, the wound should be enlarged by removing a portion of rib, prolapsed omentum tied off, the gastric wound sutured, the diaphragm also closed, and the pleural cavity drained by a strip of gauze.

Foreign bodies in the stomach.—A foreign body may be swallowed *accidentally*, such as a tooth-plate, etc., or *intentionally*, as coins, knives, forks, spoons, nails by jugglers or thieves, or by the insane. Balls of hair, etc., occasionally collect in the stomach through the habitual biting off and swallowing the ends of hair or cotton, or a Murphy's button may fall back into the stomach after gastro-enterostomy. A needle fixed in the mucous membrane may cause persistent vomiting, a fish-bone lying athwart the pylorus great pain and pyloric obstruction. The evidence of a foreign body lodging in the stomach may be gathered from the history of the case, the permeability of the œsophagus, gastric disturbance, and in the case of large objects, like knives, forks, and hair balls, by palpation. But by far the best evidence is obtained by the *x* rays, a coin being placed on the umbilicus as a guide. This affords positive evidence of practically all objects, for even hair balls may be expected to cast a shadow. *Treatment.*—With a few exceptions a foreign body should be at once removed by gastrotomy. Small coins, smooth objects like buttons, including Murphy's button, closed safety-pins, etc., have remained in the stomach for some time, and have then been passed per anum, or exceptionally have been vomited. Generally speaking, perforation is likely to ensue into the abdominal cavity, and only

rarely have the foreign bodies escaped into a perigastric abscess and thence through the abdominal wall. The abdominal parietes having been opened by a median epigastric incision, a longitudinal incision is made into the stomach midway between the two curvatures of such a size that the object can be easily extracted without bruising the edges; the stomach wound is then closed by a double row of sutures. The peritoneum must be well protected, for hair balls in particular are generally very foul. The abdominal wound should be closed in the ordinary manner unless there is already a perigastric abscess, when a drain must be kept in for a few days.

Injuries to the liver.—There is always a free escape of venous blood. *Rupture* without external wound is diagnosed by the history of the accident, a crush or severe blow over the liver, followed by marked collapse and pallor and increase of liver-dulness from concealed hæmorrhage. When these signs are marked an incision is required to arrest the hæmorrhage. *Punctured wounds* of the liver are known by the very dark venous blood which oozes freely.

The hæmorrhage is easily controlled by direct pressure. In suitable cases sutures may be used to approximate the edges of the liver wound. Blood-clot is cleared out, gauze firmly packed against the bleeding surfaces, and the ends brought out of the wound. Some of the gauze strip is drawn out daily.

Injuries to the gall-bladder and gall-ducts.—Bile not previously infected is slow in setting up peritonitis, and may collect in the peritoneal cavity in very large quantities without doing so. On the other hand, the extravasated bile may become shut off by adhesions. Increase of liver-dulness, without the marked collapse and signs of concealed hæmorrhage attending rupture of the liver, but with some jaundice, indicates a *rupture* of the gall-bladder or duct; a *punctured* wound is shown by bile escaping. *Treatment.*—The gall-bladder and bile-duct are exposed (see *Diseases of Gall-Bladder*) and the wound sewn up, or if it cannot be discovered quickly, the area is cleared of extravasated bile and the wound packed with gauze. In the latter case the escape of bile usually stops quickly. Only when the common duct has been completely divided will a fistula persist, in which case a second operation will be required, either to close it or to set up an anastomosis between the gall-bladder and duodenum.

Injuries to the spleen.—The spleen may be ruptured without an external wound, from a crush, also from a blow, even quite a slight one when the spleen has become enlarged from malaria. A fall on the abdomen, running in the dark against a post, the kick of a soldier to awaken a sleeping punkah coolie, are instances. Collapse, acute anæmia and increased splenic dulness mark the accident, and the profuse hæmorrhage into the peritoneum may prove rapidly fatal. A punctured wound of the spleen bleeds freely, and the blood is bright red, as compared with the dark blood from the liver, bright frothy blood from the lung, and blood mixed with

the acid contents from a stomach wound. If the blood comes from a wound of the heart the lesion is indicated by the sudden and extreme collapse. The spleen may *prolapse* through an incised wound, and then becomes enormously swollen by venous congestion. *Treatment.*—In any case of doubt an exploration should be made, and the pedicle of the spleen seized between the thumb and finger, then clamped, the blood-clot turned out, and the spleen excised after carefully applying a pedicle ligature. In a recent case, under the care of Mr. D'Arcy Power, the wound in the spleen was successfully plugged with gauze.

Injuries to the pancreas.—The pancreas may be *crushed* by an accident, *e.g.*, by being run over. Crushing has also been done by an abdominal tourniquet. Stabs and bullets cause *perforating wounds* with hæmorrhage and escape of pancreatic secretion. Fat necrosis and fatal gangrene (see *Diseases of the Pancreas*) may follow, also a cyst or pancreatic fistula. A bullet wound of the pancreas has been successfully closed by suture.

Foreign bodies in the peritoneal cavity.—A foreign body may reach the peritoneal cavity from without by accidental perforation of the abdominal wall, or having been swallowed or may ulcerate into it from the stomach or intestines. A third source arises during operation: clamp forceps, marine sponges, pads and strips of gauze, not having been counted beforehand or held by strings, may be overlooked and left in the peritoneal cavity. In a great number of cases localised suppuration is set up which proves fatal. Or after more or less disturbance the foreign body may ulcerate out through the abdominal wall or by the bladder, vagina or rectum. The diagnosis is formed partly by the history of the case, partly by palpation, the outline of the foreign body being felt surrounded by inflammation, and by the *x* rays, the most important aid of all except in the case of sponges and gauze. As soon as it is discovered the foreign body must be removed.

Traumatic peritonitis may be set up by any of the injuries above described, and may either remain *localised* to the neighbourhood of the wound or other injury, or when septic become *diffused* over the whole peritoneal cavity and terminate fatally.

The *localised simple peritonitis*, after gluing the parts together, and thus preventing the spread of the inflammation, subsides, but if septic terminates in suppuration and the formation of a circumscribed abscess, which may burst externally or into the intestine, or into the general peritoneal cavity then setting up diffuse peritonitis. The *diffuse septic variety* is generally due to: 1, perforation of the stomach or intestine, and extravasation of their contents; 2, gangrene of a loop of intestine resulting from internal strangulation, or following on replacement of the bowel into the abdomen after an operation for strangulated hernia; 3, gangrenous or perforating appendicitis, or the rupture of an abscess at first

localised to the region of the appendix; 4, the bursting of any other kind of abscess into the peritoneal cavity, such as a pyo-salpinx or a suppurating ovarian cyst; 5, extravasation of urine, bile, or blood; 6, septic infection during an operation, or from leaving a sponge, etc., in the peritoneal cavity; 7, failure of intestinal union, *e.g.*, leakage along a stitch which has perforated the mucous membrane, sloughing out of a Murphy's button, paralysis of the gut, mesenteric thrombosis, an accidental wound of the intestine; and 8, imperfect closure of a ruptured bladder.

Pathology.—The intestines at first red and congested soon become distended with gas, and their surface, at first sticky, later becomes coated with layers of yellowish-green fibrin, which glues adjacent coils together, whilst at other spots they are separated by the sero-purulent fluid poured out from their inflamed surface. Later the whole peritoneal cavity becomes filled with this purulent fluid or pus, in which masses of flocculent fibrin float. In addition to the ordinary pyogenic micrococci the *bacillus coli communis* and the *pneumococcus* often appear to be the organisms at work. The *bacillus coli communis*, which is always found in the intestine, appears able to escape through the walls of the gut and infect the peritoneum when there is any breach or other alteration in the serous coat. The diffuse variety practically always terminates fatally, unless surgical measures are taken, sometimes in a few hours, usually within a week or ten days, from collapse and blood-poisoning due to the absorption of septic products. Should recovery occur, death may subsequently ensue from intestinal obstruction consequent upon the gluing together of the intestines or the strangulation of a loop by a band of adhesion.

Symptoms.—In the *local form* there is severe pain at one part of the abdomen, increased on pressure, on deep inspiration, and on coughing, with perhaps vomiting, and a slight rise of temperature, followed, should an abscess form, by a circumscribed swelling, rigors, and fever. In the *diffuse variety* the pain, which at first may be localised to the seat of wound or injury, or referred to the umbilicus, becomes general and of a lancinating character, and so increased by the slightest pressure that the weight of the bed-clothes in a severe case cannot be borne. The patient lies on his back with his legs drawn up to relax the abdominal parietes, his breathing being entirely thoracic. The abdomen is at first hard owing to the spasmodic contraction of the muscles, but soon becomes distended and tympanitic, the paralysis of the muscular coat of the intestines allowing them to become inflated with gas. Where the peritonitis is the result of perforation the free gas in the peritoneal cavity may efface completely the liver-dulness. Later, as effusion occurs, the abdomen may become dull in the flanks. The general symptoms are obstinate vomiting, usually constipation, hiccough, a furred, dry, and brown tongue, a small, quick (140 to 160), and

wiry pulse, which later becomes weak, very rapid and compressible, and exhaustion and collapse. The temperature may register 103° or 104°, but it generally falls as toxinæmia sets in from absorption of the septic products, and may be subnormal before death; at times it may remain little, if at all, raised throughout. Later the extremities grow cold, the face becomes pinched and worn, and the patient dies of collapse and toxinæmia.

The prevention of traumatic peritonitis turns first of all on the diagnosis. Cases suitable for expectant treatment are dealt with as mentioned on p. 531. For all other cases a prompt operation, with all aseptic care, which discovers and treats the whole extent of the injury, is the only measure.

Treatment.—A local simple peritonitis is relieved by fomentations, to which belladonna or opium are added, or turpentine stupes; occasionally leeches may be applied, or if the inflammation be subacute, blisters or counter-irritation with iodine. The bowels should be moved, the patient kept in bed until all pain has subsided, and fed carefully. Signs of local suppuration, such as is described under the heading of *Appendix Abscess*, indicate immediate incision.

General Treatment after an operation for injury of the abdominal viscera. The patient must be kept absolutely at rest with the shoulders slightly raised, so that should any septic material escape into the peritoneal cavity it may gravitate downwards. He should be moved as little as possible, but there is no need to maintain the dorsal position; often a little turn to one side or the other may give relief. Generally the treatment follows the directions laid down on p. 192. Collapse requires that nutrient enemata, with ʒss. to ʒj. of brandy, be given immediately after the operation. A saline infusion, rectal, subcutaneous or intravenous, is indicated for hæmorrhage, extreme collapse, and also when there is general septic peritonitis. Not only should it be given during or immediately after the operation, but in severe cases it can be repeated, as also may strychnine injections, with great advantage. Thirst may be relieved by a wet pack, *i.e.*, the patient's arms and legs are wrapped in wet towels covered with blankets, by which means the skin absorbs much fluid. It has been shown by experiment that an intestinal or other intra-peritoneal wound which has been united gradually becomes weaker until the fifth day, after which it gets rapidly firmer. Hence a movement of the bowels on the second day finds the intestines still firmly held by the suture or button. A rectal enema is generally to be preferred to an aperient by the mouth in extensive wounds of the intestine. It should be given on the second day, and repeated if necessary until passage of flatus at least is obtained, but there is no necessity for a large motion. A continuance of vomiting beyond that caused by the anæsthetic should usually be treated by an injection of morphine, $\frac{1}{3}$ gr., and atropin $\frac{1}{100}$ gr., after each attack. If it be kept up by the regurgitation of bile or fæces into the stomach, the

patient should be induced to drink all at once a pint of warm water, which will quickly be returned, and the stomach by this means washed out with less disturbance to the patient than the passage of a stomach tube, unless he has previously been accustomed to this latter. Nothing should be given by the mouth as a rule except hot water until vomiting has ceased, the strength being meanwhile kept up by nutrient enemata. However, sips of champagne or brandy and water every fifteen minutes may be of service. Ice or ice-cold water should be very sparingly given, and only at the wish of the patient. The desires of the patient may generally serve as a guide as to the feeding, small quantities of beef essence, milk and water, or soda and milk, often half a cup of freshly-made tea, gives great satisfaction; sometimes lumps of cold jelly or whey can be kept down. As to the increase of food, a healthy patient recovering rapidly will often do much better if hurried on to a solid diet, for a fluid diet of milk, etc., only produces flatus and constipation. On the other hand, a weak patient after severe peritonitis and adhesions, etc., may require to be checked, the appetite going beyond the digestive powers.

Septic peritonitis having supervened after an injury, the only chance for the patient is an immediate operation. If it follow after an operation, the question must be asked, Is it due to anything which has been left undone or to some subsequent accident? Usually after operating in doubtful cases a gauze drain or glass tube, or both, are left in the wound, but supposing the wound to have been closed, the onset of septic peritonitis may indicate the reopening of the wound, clearing out again all septic material, and plugging with gauze, or the insertion of a glass tube down into the pelvic pouch through a small opening in the hypogastrium. The rapid distension of the bowels with continuous vomiting may indicate a kink or other form of intestinal obstruction, to relieve which the wound must be reopened at once. A collection of gas in the peritoneal cavity will point to a wounded coil having been overlooked, or imperfectly closed; free fluid in the peritoneal cavity, whether pus, urine, bile, or blood, in all cases requires removal. On the other hand, if the patient's symptoms point to intestinal paralysis the surgeon will usually refrain from disturbing him further. A failure to improve, with a rising pulse, dry, brown glazed tongue, shrunken, pinched, earthy look, a low delirium, refusal of food, without marked vomiting except after food, constipation, but no pronounced abdominal distension, indeed no particular indication for further operative measures—all point to the patient being let alone.

Injuries of the kidneys and ureters.—*Rupture* of the kidney and its complications have been referred to on p. 526. An incised or lacerated wound of the loin may be accompanied by *prolapse* of the kidney.

Wounds of the kidney.—Wounds of the kidney may be inflicted by stabs in the loin or gunshot injuries. When inflicted from the front the peritoneal cavity is involved. Such wounds are

attended by pain in the loin darting to the thigh and testicle, nausea and vomiting, hæmorrhage often severe from the wound, into the tissues or into the peritoneal cavity, escape of urine through the wound or extravasation of urine behind the peritoneum or into the peritoneal cavity if the peritoneum is torn. Micturition is frequent, and blood will also appear in the urine. The dangers are hæmorrhage, extravasation of urine, peritonitis, and perinephritic abscess. The prognosis is very unfavourable if there is much extravasation of blood and urine, if there is a foreign body in the wound, or if the peritoneum is torn. *Treatment.*—The wound should be thoroughly cleansed and enlarged if necessary after the skin around has first been rendered aseptic; any foreign body should be removed, and the peritoneum if torn closed by sutures, unless there are reasons for thinking the wound was inflicted with a septic instrument, when a gauze drain should be inserted. If hæmorrhage cannot be controlled by ligature or plugging, the kidney may have to be removed.

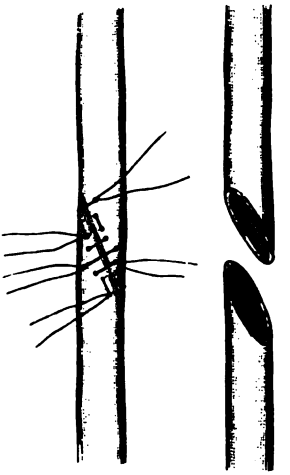


FIG. 231.—Bovée's oblique method of uniting the ureter. (Annals of Surgery, Part 49, and Morris' Renal Surgery.)

Wounds of the ureter.—Rupture of the ureter may occur from an abdominal crush (see *Rupture of Viscera*), or may be accidentally inflicted during such operations as abdominal hysterectomy for myoma, and the removal of a cancerous uterus, or of tumours deep in the broad ligament. It is also sometimes divided in vaginal hysterectomy, and has been injured in high excision of the rectum. The urine may infiltrate the subperitoneal tissues, leading to the formation of an abscess, escape by the operation wound and cause a urinary fistula, or enter the peritoneal cavity and set up acute peritonitis within a day or two. *Treatment.*—The wound, if small, may be closed by Lembert's sutures; if large and ragged, or the tube is completely divided, continuity may be restored, after removing the lacerated portion, by Bovée's oblique method (Fig. 231), or by Van Hook's method of lateral implantation (Fig. 232), or by re-implantation of the proximal cut end into the bladder. This failing the kidney may have to be removed, or the ureter ligatured in order to produce functional atrophy of the kidney, or if the opposite kidney be abnormal, a urinary fistula must be established in the loin or the ureter inserted into the intestine.

INJURIES OF THE PELVIS AND PELVIC VISCERA.

Fractures of the pelvis.—*Cause.*—Nearly always severe and direct violence, as the passage of the wheel of a heavy van, or a crush between the buffers of railway carriages. The acetabulum, however, especially in old people, may be fractured from a fall on the great trochanter, or its rim may be chipped off in conjunction with dislocation of the hip.

State of the parts.—The injury may be localised to the acetabulum, or to the ramus of the pubes or ischium; or merely the

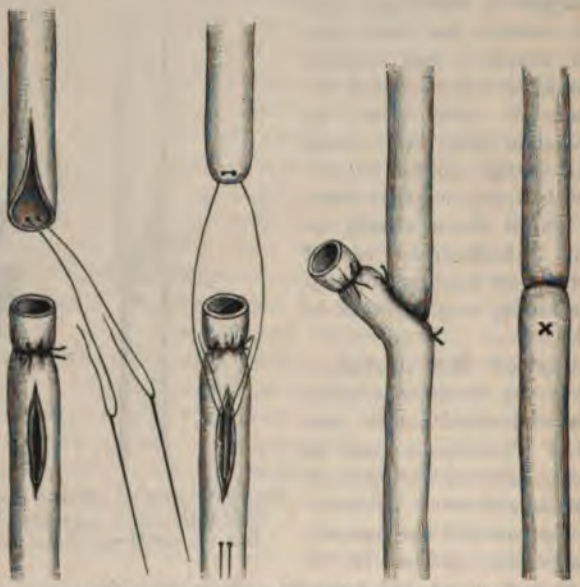


FIG. 232.—Van Hook's lateral implantation method of uniting the ureter. (Journal of American Medical Association, and Morris' Renal Surgery.)

anterior superior iliac spine or the crest of the ilium may be splintered off. When the result of a crush, the injury is generally more severe, the line of fracture often extending through the ramus of the pubes or ischium, and thence backwards through the ilium near the sacro-iliac synchondrosis, thus detaching, as it were, one side of the pelvis from the other. Or the fracture, as shown in Fig. 233, may extend in various directions, more or less smashing both the false and true pelvis. At times the injury may be limited to a separation of the pubic symphysis or of the sacro-iliac symphysis, or even of both, when it is spoken of as dislocation of the innominate bone. The fracture owes its importance to the liability of the pelvic viscera to be injured. Thus the bladder is not infrequently

ruptured; or the urethra torn across by a fragment of the pubic arch; or the rectum or intestines lacerated when the sacrum or the venter of the ilium is implicated.

Signs.—The history of the accident, and perhaps the mark of a wheel across the lower part of the body, will commonly direct attention to the possibility of a fracture. On grasping the crests of the ilia firmly, preternatural mobility or crepitus may be discovered and pain produced, whilst the patient is usually unable to walk or to turn himself in bed without great suffering. A displaced fragment may sometimes be felt through the vagina or rectum or wound in the perineum. There is usually considerable shock, and where any of the viscera have been ruptured, commonly severe collapse. (See *Rupture of Bladder, Urethra, etc.*)

Treatment.—As the bone readily unites, little beyond keeping the parts at rest and in apposition is required. This may be done by

Fig. 233.—Fracture of the pelvis. (Bryant's Surgery.)

applying a flannel bandage firmly round the pelvis and confining the patient to bed for three to five weeks, according to the severity of the fracture. Where there has been much crushing a gutta-percha or poroplastic felt shield should be moulded to the pelvis and hip of the affected side to prevent any movement of the fragments by the use of the joint. In any case a catheter should be passed in order to make sure that the urinary apparatus is not injured.

Fracture of the acetabulum.—The rim of the acetabulum, generally the posterior and upper part, may be broken off in some forms of dislocation of the femur on to the dorsum ilii. Besides the ordinary symptoms of the dislocation, crepitus will generally be detected on manipulation, and the head of the femur will slip in and out of the acetabulum. Or the fracture may extend through the floor of the acetabulum, the head of the bone being even driven into the pelvis. Crepitus may then be detected; or the head of the bone may be immovably fixed and the limb shortened. Pain is present on movement or on attempting to stand on the limb, also sometimes on

pressing on the pubes. *Treatment.*—Extension may be made by a long splint, or with a stirrup, weight and pulley.

Fracture of the sacrum may occur as the result of severe direct violence, and as it is generally comminuted and involves the lower sacral nerves, is liable to be accompanied by paralysis of the bladder and rectum. If a portion of the bone is found pressing on the rectum it should be replaced if possible.

Fracture of the coccyx is occasionally met with from falls or blows on the nates. It is attended by pain on sitting, walking, coughing, and defæcation, owing to the attachment of the coccygei muscles which form part of the floor of the pelvis. Increased mobility, deformity, and crepitus may be felt with the thumb over the bone and forefinger in rectum. A fall or blow on the bone with or without fracture may give rise to intense and long-continued neuralgia (*coccygodynia*), necessitating the excision of the coccyx.

Rupture of the bladder nearly always occurs when the viscus is full. It may then be due to a blow or kick upon the abdomen, and is a frequent complication of fracture of the pelvis. Rupture is seldom due to over-distension consequent upon urethral stricture, as the walls of the bladder are then generally thickened and thereby rendered capable of resisting the pressure of the contained urine. Under these circumstances it is commonly the dilated urethra behind the stricture that gives way.

State of the parts.—The rupture, which is usually vertical, may extend through the posterior part of the bladder, the urine escaping into the peritoneal cavity; or through the anterior part, the urine then being extravasated into the loose cellular tissue of the pelvis. In the former case, which is the more common, acute peritonitis is generally set up sooner or later, according to the condition of the urine, and is, as a rule, fatal in a few days. In the latter, diffuse cellulitis commonly occurs, the patient succumbing either to septic intoxication from the absorption of the products of urinary decomposition or to the extension of the inflammation to the peritoneum.

Signs.—Intense collapse following a blow over the abdomen or a severe injury of the pelvis, combined with the fact that on passing a catheter (as should always be done in such a case) no urine but only a little blood escapes, whilst the patient states that the bladder was full at the time of the accident, or at least that he had passed no water for several hours previously, should lead us to infer that the bladder is ruptured. The catheter, moreover, may at times be felt to be grasped by the empty bladder, and to slip through the rent in its walls; the point may then be detected more plainly than natural through the front of the abdomen, and blood-stained urine may flow. The flow, however, is not continuous, but varies with respiration. If the urine has had time to collect in the peritoneum, a sensation of fluid in the abdomen may be detected on palpation. Later, symptoms of peritonitis or of pelvic cellulitis will probably

supervene. *Diagnosis.*—The signs, however, are not always obvious. Thus, there may be neither collapse nor pain; or, again, on passing a catheter, several ounces of clear urine may escape owing to urine having collected in the bladder in consequence of the rent being small, or valvular or blocked by a portion of intestine. If in doubt, ten or twelve ounces of some antiseptic fluid may be injected into the bladder, when, if no rupture exists, the bladder will rise out of the pelvis as during ordinary distension, and the same quantity should flow out again through the catheter. Or the bladder may be inflated with air or hydrogen: if there is an intra-peritoneal rupture the abdomen becomes distended and the liver-dulness lost; if the bladder is sound a localised tympanitic tumour rises from the pelvis. In a case of ruptured bladder under Walsham's care the signs were obscure and the fluid test was not conclusive. Injection through a catheter of a few cubic inches of air by the aid of the rubber-ball of an ether-spray apparatus sets the diagnosis completely at rest. The conclusions drawn from the experience of this case, the first in which the test has been applied, are—1, a few cubic inches of air is sufficient; 2, only very moderate pressure need be used; and 3, the introduction of air gives rise to profound shock, which passes off as soon as the abdomen is opened and the air let out. The air-test will probably enable the diagnosis to be drawn between an intra- and extra-peritoneal rupture, since in the latter emphysema of the connective tissue instead of distension of the peritoneum would probably be produced.

Fig. 234.

Fig. 235.

Figs. 234 and 235.—Method of applying Lembert's suture in ruptured bladder. (After Sir W. MacCormac.)

Treatment.—When the rupture is intra-peritoneal the abdomen should be immediately opened and the rent in the bladder sewn up. Many cases have now been treated successfully in this way: amongst the first of these may be mentioned, two by Sir William MacCormac, one by Mr. Holmes, and two by one of us (Walsham). In sewing up the bladder the peritoneal surfaces should be brought into contact by Lembert's sutures (Figs. 234, 235), which should not pass through the mucous membrane. And one suture at least should be placed beyond the angles of the wound so as to prevent leakage at these spots (Fig. 234). After the rent has been closed a coloured antiseptic fluid should be injected into the bladder to make sure that the viscus is water-tight. The peritoneum should be then flushed out with boric-acid lotion and the external wound closed. A catheter should not be tied in the bladder for fear of its inducing

septic changes in the urine, but the patient should be made to regularly empty his bladder every four hours to guard against over-distension and the giving way of the sutures. When the margins of the rent are lacerated, they should be pared to admit of coaptation, or a long drain tube should be inserted in the bladder, and the peritoneal cavity around, after being cleansed, packed with iodoform gauze. When it is not clear whether the rupture is intra- or extra-peritoneal, the fundus of the bladder should be exposed before opening the reflection of the peritoneum. Extra-peritoneal rupture should be treated by a free incision in the perineum, also above the pubes if needed, and freely drained. Nothing, as a rule, should be given by the mouth for the first twelve or twenty-four hours. Where, however, there is extreme collapse, stimulants may be cautiously administered by the mouth or rectum. As in other peritoneal cases, morphine should be used if there is pain.

Wounds of the bladder.—The bladder may be wounded in any penetrating wound of the abdomen, as by a stab with a knife or bayonet or gunshot, or through the sciatic notch, or per rectum or vaginam, or during an operation for hernia, in which the bladder is prolapsed in the sac or is drawn therein whilst twisting the neck of the sac. The symptoms are similar to those of rupture, but the diagnosis is made, seeing that there is already a wound of the abdominal parietes, by exploring with the finger. The treatment consists in closing the wound as in rupture, viz., by an intra-peritoneal operation.

Rupture of the urethra is a serious injury, as it exposes the patient not only to the immediate danger of extravasation of urine, but also to the lifelong trouble of a traumatic stricture. It is generally caused by a kick on the perineum, a fall astride a joist or rail, or the displacement of a fragment of the pubic arch in fracture of the pelvis. The urethra may also give way behind an old stricture while the patient is straining to empty his bladder.

State of the parts.—The rupture usually occurs where the urethra passes under the pubic arch, *i.e.*, either just in front of or just behind the anterior layer of the triangular ligament. In the former situation urine and blood will be extravasated into the perineum; in the latter, about the neck of the bladder. As the triangular ligament, however, is generally torn, some urine will, as a rule, in the latter case also pass forward into the perineum. The urethra may be completely torn across, or the rupture may only be partial, the upper wall escaping.

The *signs* are usually quite obvious. Together with the history of an accident, there will be some shock, pain, swelling, and ecchymosis of the perineum, and escape of blood, often in considerable quantities, into the scrotum and from the urethra. The patient is unable to pass water, and any attempt to do so gives pain and forces urine into the tissues of the perineum, and thence into the

scrotum, which becomes greatly swollen and œdematous. On trying to pass a catheter some obstruction is generally met with, and will often prove insurmountable; but if the catheter is finally passed, clear urine will escape. These signs distinguish it from ruptured bladder, in which injury the catheter passes easily, but as a rule (although the bladder is said to have been full at the time of the injury) only a little urine flows. In mere bruising and ecchymosis of the perineum the catheter will pass easily, and there is, as a rule, no escape of blood from the urethra.

Treatment.—In slight cases in which there is probably a mere bruising of the urethra and no retention of urine, all that is necessary is rest in bed and careful watching for any sign of extravasation into the perineum. If there is retention a soft catheter should be passed if possible; if not, a gum-elastic or a silver one, which should be tied in for three or four days. Failing to pass a catheter or extravasation of urine in any quantity having already occurred, a silver catheter should be passed down to the obstruction, and a free incision through the middle line of the perineum made upon its point. The scrotum should also be incised if infiltrated with urine. If the proximal end of the torn urethra can now be found, the catheter should be passed through it into the bladder and tied in. If not readily discovered, a prolonged search for it need not be made, as with a free incision through the perineum there is no danger of further extravasation of urine, and a catheter will probably pass after a few days. If, however, the catheter cannot then be made to enter the bladder, a supra-pubic cystotomy is required to pass the catheter *from* the bladder. If the urethra is found only partially torn across, or if, though completely divided, its ends can be brought together, an attempt should be made to restore the canal by suture over a catheter, the external wound in the perineum being filled with gauze. The catheter should be kept in for a week. Complete suture of the perineal wound is attended with some risk of extravasation, and could not be done where extravasation had already occurred on account of the softened condition of the tissues. Should a fragment of the pubic arch be found compressing the urethra, steps must be taken to remove it, the bladder in the meantime being aspirated above the pubes to prevent further extravasation occurring. When the wound in the perineum has to be left to granulate, a silver catheter, as the point of this is more under control than that of a soft one, should be passed daily during the healing of the wound, and the patient enjoined subsequently to pass one for himself at frequent intervals, and warned that if he neglects to do so a stricture will gradually form. A subsequent excision of the stricture may be advisable in some cases.

Injuries of the rectum occasionally occur from falls upon a sharp-pointed body, or incautious attempts to pass a long enema-tube or bougie. Should the peritoneal cavity be perforated, death is the

almost invariable consequence of expectant treatment, especially if any injection has been thrown into the peritoneum before the mistake is discovered. *Treatment.*—Opening the abdomen, flushing out the peritoneum, and sewing up the rent in the gut, holds out the only chance of escape.

Foreign bodies in the rectum.—Foreign bodies of the most varied descriptions have at times been accidentally or intentionally introduced into the rectum. Fish-bones that have been swallowed not infrequently become impacted just within the anus, there giving rise to much irritation or pain, and often causing an ischio-rectal abscess. The removal of some of the bodies introduced apparently to relieve, when of large size, is frequently attended with considerable difficulty, requiring an anæsthetic, dilatation of the sphincter, and the use of various forceps, or even the passage of the whole hand, or a sacral incision as in Kraske's operation. In a case under the care of Mr. Willett, the foreign body, a Liebig's extract-of-meat jar, could not be removed till the peritoneal cavity had been opened and the jar forced down by the hand.

Injuries of the pudenda.—Contusions and wounds of all kinds may be met with, and require no special remark further than:—that ecchymosis of the loose cellular tissue is often extensive; that wounds, though apt to be attended with considerable hæmorrhage from the great vascularity of the parts, on this account also heal very readily, and that serious consequences from such injuries are exceedingly rare.

Hæmatoma of the labia majora sometimes occurs from injury, especially during pregnancy or parturition, the parts being congested at those times. The tumour may attain a large size, owing to the laxity of the tissues. The blood generally becomes absorbed, but suppuration may occur or the blood become encysted. The application of ice will generally control the hæmorrhage. A hæmatoma should on no account be opened unless suppuration takes place, when a free incision should be made, clots turned out, and the cavity filled with gauze.

Wounds of the vagina perhaps more frequently fall under the care of the obstetrician than of the surgeon. The surgeon, however, may be called upon to arrest hæmorrhage from this canal, consequent upon laceration inflicted by falling upon some sharp object, or the introduction of a foreign body. Washing out, the application of sutures, or, if necessary, careful plugging with antiseptic gauze, will usually suffice.

Perforation of the walls of the vagina, with injury of the bladder, peritoneum, or intestines, is the occasional result of wounds of the vagina, and may prove fatal. The vagina should be washed out and the wound sutured or plugged with strips of iodoform gauze. The peritoneal cavity, if involved, should be irrigated on any sign of peritonitis.

Foreign bodies in the vagina.—Pessaries that have been introduced and forgotten by the patient, or possibly without her

knowledge, are the foreign bodies most frequently found in the vagina, but various other articles have at times been met with. Their long retention is often productive of a foul-smelling discharge, and may lead to the perforation of the walls of the rectum or bladder and an incurable fistula.

Foreign bodies in the female urethra and bladder.—Hair-pins introduced with the bent end forwards, are not infrequently pushed up the urethra into the bladder, where, if allowed to remain, they become encrusted with phosphates, and give rise to symptoms of stone. The urethra should be dilated, and the sharp ends of the hair-pin grasped by forceps, snared in a tube, or in some such way removed.

Ruptured perineum occasionally occurs during first, and especially instrumental labours. It is a tear down the middle line, as if cut by a knife. There may be a mere rent in the fourchette; or the rupture may extend from the vagina through the sphincter ani into the rectum, and involve more or less of the recto vaginal septum.

Symptoms.—A rupture, when slight, gives rise to no special trouble; but when more extensive, there may be some prolapse of the posterior wall of the vagina with the contiguous wall of the rectum (*rectocele*), or of the anterior wall of the vagina and the part of the bladder in contact with it (*cystocele*), and, perhaps, some prolapse of the uterus. There may also be frequent micturition, and when the sphincter ani is involved, occasional incontinence of fæces. If the perineum is not sewn up immediately after the rupture the anterior end, *i.e.*, the vaginal mucous membrane, unites with the posterior end, *i.e.*, the rectal mucous membrane, so that the union of the sides is prevented and they remain wide apart. On viewing an old ruptured perineum, therefore, a transverse ridge marks the lower end of the recto-vaginal septum where the vaginal and rectal mucous membranes have come into contact.

Treatment.—An attempt to unite the parts should always be made immediately after the rupture by sewing up first the mucous membrane of the vagina, then that of the rectum, and lastly the skin of the perineum by sutures inserted deeply. Should this fail, a plastic operation should not be undertaken until the vaginal discharge has ceased, the child been weaned, and the general health restored. The patient in the meantime should not be allowed to walk about for fear of a prolapse of the parts. The bowels having been cleared by an aperient, and the rectum on the morning of the operation by an enema, the patient should be placed in the lithotomy position. *The older operation.*—The skin is dissected up from the sides of the fissure, and the mucous membrane from the recto-vaginal septum, so as to leave a raw surface of the size and shape shown in Fig. 236. The skin and mucous membrane, however, should not be cut away as shown in the figure, but reflected towards the vagina.

Care should be taken that the tissues are clean cut, and that the raw surface of the recto-vaginal septum is at least an inch broad, so that immediate and firm union where the parts are brought together may be obtained. Three or more deep sutures, consisting of strong silk-worm-gut, should be introduced by means of a perineal needle. The first should be passed about an inch from the margin of the rupture deeply through the recto-vaginal septum, and, if the sphincter is ruptured, through its stump, and out at the corresponding spot on the opposite side. The next two sutures should be passed in the same way, only not through the septum. Fig. 236 shows the appearance presented by the sutures when *in situ* and ready for tying. The posterior suture should be first secured. Superficial sutures, after the fissure has been drawn together by the deep, should be used to keep the edges of the skin in contact. If there appears to be any tension, "incisions of relief" may be made through the skin on either side. *The newer method* consists in making incisions like the letter H, the transverse splitting the recto-vaginal septum and the longitudinal extending along the sides of the vulva and anus. If the vaginal mucous membrane is now drawn well forwards and that of the rectum backwards, the wound is restored to the state it was in immediately after the rupture. Sutures may now be inserted as in a recent case, except that the perineal sutures, and especially the hindermost one (the "purse-string suture"), must be inserted more deeply in order to pull down the recto-vaginal septum and so restore again the perineal body. This method has the advantage that no tissue is pared away.

Fig. 236.—Operation for ruptured perineum.

After-treatment.—It is better not to apply any fixed dressing; the nurse should as often as fæcal mucus escapes, wipe it away, dust with iodoform, and keep a gauze pad under the perineum. The patient should lie perfectly quiet on her back with the legs tied together, and the knees over a pillow, and should keep her bed for at least three weeks. The urine should be passed on the hands and knees or be drawn off by the catheter. Some surgeons keep the bowels confined for three days to ensure rest to the wound, but as the fæcal relief may then endanger the adhesions, it is perhaps better to ensure a soft daily motion by gentle laxatives. The deep

sutures may be removed at the end of a week or ten days, or left in until loose, the parts in the meanwhile being kept clean by gentle syringing with an antiseptic lotion. Where the posterior or anterior wall of the vagina is much prolapsed, a wedge-shaped piece of mucous membrane may be removed, and the edges of the incision brought together by suture.

Injuries of the scrotum and testicle.—Incised wounds of the scrotum and penis are rare. They bleed freely but readily heal in consequence of their abundant blood supply. Contused wounds of the scrotum are often attended with much extravasation of blood, giving the parts a black and swollen appearance, and are apt to be followed by sloughing. Should such threaten free incisions must be made. Extravasation of blood into the tunica vaginalis (*hæmatocele*), and inflammation of the testicle (*orchitis*), both of which may follow a blow or other injury of the parts, are described under *Diseases of the Testicle.*

Rupture or fracture and dislocation of the penis into the scrotum are of very rare occurrence as a consequence of a squeeze or crush.

Ligature of the penis.—A piece of string is sometimes tied round the penis by children either in play, or to prevent themselves wetting the bed. Great swelling in front of the constriction ensues, and if the cause is not recognised and removed, the string will soon cut deeply into the penis, and may even divide the urethra.

Rupture of the frænum.—Quite severe hæmorrhage may follow when the artery is only partly torn across; when completely divided the hæmorrhage will cease, or the proximal end may be tied.

Foreign bodies in the male urethra and bladder.—Pieces of slate pencil, beads, wax bougie, and the like, are sometimes passed by boys or by the insane into their urethra, and not infrequently a piece of damaged gum-elastic or black catheter is broken off during catheterisation. An attempt should be made to remove the foreign body by manipulation with the fingers, or by the introduction of various urethral forceps, or by asking the patient to first close the meatus with the finger and thumb, to make a forcible attempt to pass water, and then suddenly to let go. If the forceps are used the urethra should be grasped, if practicable, behind the foreign body, lest it be pushed back into the bladder. These means failing, it may be pushed back into the bladder, broken up by a lithotrite, and washed out by the evacuator, or, if soft, grasped with the lithotrite and extracted whole. A piece of soft catheter may readily be removed in this way. If the foreign body cannot be pushed into the bladder, it must be cut down upon and extracted through an incision in the middle line of the urethra. A pin introduced head first should have the point thrust out through the skin up to the head. The head can thus be reversed, and may so be pushed out through the meatus. An ear of corn or piece of grass introduced

with the awns pointing towards the meatus is very difficult to extract, and generally requires an incision into the urethra through the perineum. If a *foreign body* is allowed to remain in the urethra it becomes encrusted with phosphates, and gives rise to symptoms of impacted calculus (which see). Foreign bodies in the bladder soon become encrusted with phosphates and cause symptoms of stone (see *Stone in the Urethra and Bladder*).

INJURIES OF THE UPPER EXTREMITY.

Bruises, contusions, burns, scalds, and frostbites of the upper extremity (see *General Pathology of Injuries*).

Sprains of the joints of the upper extremity, especially of the wrist, are very common. Rest, the application of cold, and in the case of the thumb, wrist, or elbow, a wet bandage followed by massage and friction with a stimulating liniment, is the usual treatment. A sprain, however slight, should never be neglected, as inflammation in or around the joint may ensue, leading to fibrous ankylosis, adhesion of the tendons to their sheaths, ganglion, etc. See *Sprains*, p. 260.

Sprains of the muscles, causing tenderness, slight swelling and pain on movement, are not infrequently met with at the wrist after hard rowing, in the supinators after tennis or other excessive exercise.

Rupture of muscles and tendons, especially the pectoralis major, the rectus femoris, the thumb and finger tendons, and the long tendon of the biceps, are not uncommon accidents. The latter may occur during any sudden and forcible action, and may be known by sudden pain, loss of power, and a gap in the course of the long tendon, whilst the inner head, on putting the muscle into action, forms a prominent lump. The long tendon of the biceps, the finger tendons, and the rectus tendon should be immediately united with kangaroo-tail tendon sutures.

Wounds of the palm are frequently attended with severe and troublesome hæmorrhage from either the superficial or deep arch. When the wound is clean cut the bleeding vessel may be tied in the usual way; but when it is of a punctured character an Esmarch's bandage should be applied, and the wound having been carefully enlarged the vessel should be sought and both ends tied. If the dissection is neatly performed with strict antiseptic precautions much less harm, if any, will be done than was often caused by the now antiquated graduated compress.

Recurrent hæmorrhage from a palmar wound which has been allowed to become septic, should be treated by ligature of the brachial artery.

Traumatic aneurysms may arise on the radial or ulnar arteries or their branches in the palm. Excision is the proper measure.

Septic wounds of the palm, when not immediately treated antiseptically, are followed by the same troubles and dangers described under *Whitlow*, p. 372.

Smashes of the hand.—After rendering the whole hand aseptic, as much as possible must be saved. After removing fragments of bone much can be done by trimming and adjusting flaps, suturing divided tendons, or fixing them to other tendons or ends of bone so that they do not retract. Digits after being quite cut off have been fixed in position and have united. The utility of even

FIG. 237.—Section of the forearm above the wrist to show the relation of the various structures. (After Braune, Esmarch and Kowalzig.) *r.* Radius; *u.* ulna; *i.m.* interosseous membrane. Muscles: *s.l.* supinator longus; *e.o.m.p.* extensor ossis metacarpi pollicis; *e.c.r.l.* extensor carpi radialis longior; *e.c.r.b.* extensor carpi radialis brevior; *e.p.i.p.* extensor primi internodii pollicis; *e.s.i.p.* extensor secundi internodii pollicis; *e.c.d.* extensor communis digitorum; *e.i.* extensor indicis; *e.m.d.* extensor minimi digiti; *e.c.u.* extensor carpi ulnaris; *p.q.* pronator quadratus; *f.c.u.* flexor carpi ulnaris; *f.d.p.* flexor profundus digitorum; *f.s.d.* flexor sublimis digitorum; *p.l.* palmaris longus; *f.l.p.* flexor longus pollicis; *f.c.r.* flexor carpi radialis. Vessels: *r.a.* radial artery; *u.a.* ulnar artery; *a.i.a.* anterior interosseous artery; *p.i.a.* posterior interosseous artery; *s.r.v.* superficial radial vein; *m.v.* median vein; *s.u.v.* superficial ulnar vein. Nerves: *m.n.* median nerve; *u.n.* ulnar nerve; *r.n.* radial nerve; *a.i.n.* anterior interosseous nerve; *p.i.n.* posterior interosseous nerve.

part of the hand is much greater if the thumb remains, or even a portion of it, however stiff. Fingers which are stiff and curved may have to be removed later if they impair the usefulness of the hand; or it may be more useful for the patient to retain the damaged digits.

A convenient dressing for the end of a finger is a square of gauze, with a notch cut towards the centre from the middle of each side.

Cut wrist.—Injuries on the palmar surface of the wrist are important on account of the danger to the median and ulnar nerves and to the tendons. As a consequence the hand may be paralysed by loss of nerve influence, or rendered useless by adhesions of the tendons about the wrist.

PLATE VIII.

Apparatus for *x* ray work with localisation bar. [From a photograph taken by Dr. Hugh Walsham.]

[*To face p.* 367.

PLATE IX.

Skiagram of a piece of needle in the foot, to show method of localising the foreign body. The shaded circle in the right lower quadrant is the photograph of a coin that is placed on the plate in order to keep the quadrants in register during the localising process. (Taken by Dr. Hugh Walsham.)

[*To face p.* 568.

to put the clavicular portion of the pectoralis major on the stretch, and carry the strapping across the back and round the front of the thorax and sew the end to the part which crosses the back (Fig. 253). Fix one end of the second strip of plaster to the sound shoulder; carry it obliquely across the back beneath the elbow (which should be pushed forwards) of the injured side, a slit being made to receive the olecranon; bring it upwards in front of the chest, and fasten it to its other end over the sound shoulder (Figs. 254 and 255). A third strip may be carried round the arm, forearm and thorax to keep the others in place. The first strip acts as a fulcrum; whilst the second, by drawing the elbow forwards forces the upper end of the humerus, with the clavicle, backwards, and at the same time keeps the shoulder raised. *b. Ellis's method* consists briefly in the use of an axillary crutch supported by two straps, the one round the chest, the other passed over the sound shoulder. The chest strap also encircles the arm and holds it firmly to the side. The forearm is further supported by a sling. *c. The axillary pad and bandage.*—Many surgeons simply place a wedge-shaped pad with the base upwards in the axilla, and then bandage the arm to the side with the elbow well raised. If the pad is used, care should be taken in bandaging lest the axillary vessels or nerves are compressed, and œdema, pain, or even gangrene of the arm be the consequence.

II. *Fracture of the acromial end of the clavicle* may occur either at or external to the insertion of the coraco-clavicular ligaments. In the former situation there is very little displacement, the fragments being held in position by the above-mentioned ligaments. Pain, crepitus, and possibly a slight gap will serve to distinguish it. When external to the ligaments the outer fragment is drawn down nearly at a right angle to the rest of the bone, so that its acromial articulation looks inwards, forwards, and slightly downwards. *Treatment.*—An axillary pad and bandage, with a moulded leather shoulder-cap to protect the parts.

III. *Fracture of the sternal end* and separation of the sternal epiphysis are very rare. *The epiphysis* is a thin disc of bone which does not appear before the seventeenth and has united by the twentieth year. It has only been found separated in one or two fatal cases.

Compound fractures of the clavicle are the result of direct violence, *e.g.*, bullets, and may be followed by necrosis and non-union. *Treatment.*—Removal of sequestra; union by suture.

The scapula.—The fracture may extend through 1, the body; 2, the acromion; 3, the coracoid process; 4, the neck; and 5, the glenoid cavity.

1. *Fracture of the body* is nearly always caused by direct violence. It may be star-shaped or transverse, or it may run vertically or obliquely through the spine; but commonly it is limited to the infraspinous fossa, and frequently the angle is alone broken off. The displacement is not usually very marked, as the fragments are well

forward dislocation (Fig. 239) the end of the bone can be felt in its abnormal situation, and can be distinguished from fracture near the sternal end by the length of the clavicle being the same on the two sides and by the absence of crepitus. The upward variety, which is very rare, may be diagnosed in the same way. In the backward, which is also rare, there is a depression at the situation of the sterno-clavicular joint, and there may be dyspnœa, dysphagia, or congestion of the head and face from pressure on the trachea, œsophagus, or veins of the neck. *Treatment.*—The forward and backward dislocations can generally be readily reduced by simply drawing back the shoulders, the knee, if necessary, being placed between the scapulæ. In the forward variety, indeed, we have always found the end of the clavicle sink into its place on laying the patient on his back. Reduction of the backward variety has at times been impossible, and excision of the end of the bone has been necessary for the relief of the severe dyspnœa which it has caused by its pressure on the trachea. The upward dislocation may be reduced by placing a pad in the axilla to act as a fulcrum and pressing the arm to the side, thus drawing the clavicle outwards. Direct pressure should at the same time be applied to the displaced end. All forms are difficult to retain in position. The best plan, perhaps, is to keep the patient constantly on his back for three weeks. If, however, he will not consent to this restraint, an endeavour may be made to retain the parts in as good a position as possible by one of the many methods of bandaging described for fracture, p. 583. We do not specially mention any here, as we have never seen or found any of them of any avail.

FIG. 239.—Dislocation of the sternal end of the clavicle forwards. (Bryant's Surgery.)

Dislocation of the acromion.—The *acromial* process of the scapula may be dislocated either, 1, upwards; or 2, downwards. Both forms are rare, but the downward is the least so. These injuries are sometimes spoken of as dislocations of the acromial end of the clavicle. *Cause.*—Commonly direct violence applied to the acromion driving it down. The *signs* are usually obvious. There is apparent lengthening of the arm with depression and slight flattening of the shoulder, and a projection in the region of the acromio-clavicular joint caused, in the *downward* form, by the acromial end of the clavicle, and in the *upward* by the acromion process. In the downward variety moreover the end of the trapezius stands out as a prominent ridge, and on pressing with one hand on the shoulder and with the other on the elbow the articular surfaces are brought

into apposition and pseudo-crepitus can be obtained. *Reduction* is as a rule easily effected by drawing the shoulders well backwards; but it is difficult to retain the bones in position in consequence of the peculiar obliquity of the articulation. This may be attempted by placing a pad over the joint and applying a strap or a bandage over the shoulder and under the elbow, and then bandaging the arm to the side. We have seen the best results from rest in the horizontal position for three weeks; few patients, however, will submit to this, nor is it possibly worth their while to do so, as little inconvenience attends the dislocation, though unreduced.

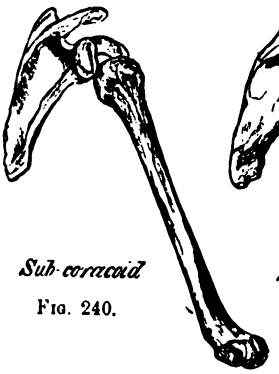
Dislocation of the shoulder is very common, a fact explained by the shallowness of the glenoid cavity, the large size and rounded shape of the head of the bone, and the powerful leverage exerted on the joint by the arm in protecting the body in falls, etc. The looseness of the capsule is an important factor in recurring cases. It is most frequent in the old and middle-aged, rare in the young, and more common in men than in women.

Cause.—Falls on the elbow or hand with the arm abducted; forcible twists of the arm; falls or blows directly upon the shoulder; and occasionally muscular action.

Varieties.—Dislocations of the shoulder may be classified according to the position of the head of the humerus into—1, forward and slightly downwards (*subcoracoid*) (Fig. 240); 2, downwards and slightly forwards (*subglenoid*) (Fig. 241); 3, backwards (*subspinous*) (Fig. 242); and 4, forwards and inwards (*subclavicular*) (Fig. 243). It is probable that when the dislocation is caused by a fall on the abducted arm the head of the bone is first forced through the lowest part of the capsule, and either remains below the glenoid cavity or is drawn upwards and inwards beneath the coracoid or clavicle, or backwards beneath the spine. An upward dislocation (*subacromial*) has been described, but this form of displacement is more generally believed to be the result of chronic osteo-arthritis. Other and rarer varieties have also been described, but appear to be merely modifications of those above enumerated.

The *signs* common to all the varieties in addition to the ordinary signs of dislocation, viz., pain, swelling, immobility, and absence of crepitus, are, 1, flattening of the shoulder; 2, prominence of the acromion; 3, a depression beneath the acromion, increased when the arm is raised; 4, a change in direction of the axis of the humerus; 5, the absence of the head of the bone from the glenoid cavity, and its presence in an abnormal situation; 6, a lowering of the anterior and posterior axillary folds; and 7, alteration in the length of the limb when compared with that of the opposite side. In doubtful cases the following tests will be found of use:—1, *Hamilton's test.* A straight edge applied to the outer side of the arm, can only be made to touch the acromion and

external condyle at the same time when the head of the humerus is absent from the glenoid cavity; 2, *Callaway's test.* A tape passed around the acromion and under the axilla will measure about two inches more on the dislocated than on the sound side; 3, *Dugas's test.* With the hand placed on the opposite shoulder, the elbow in a dislocation cannot be made to touch the chest; 4, *Humphry's test.* If the great tuberosity of the humerus can be



Sub-coracoid

FIG. 240.

Sub-glenoid

FIG. 241.

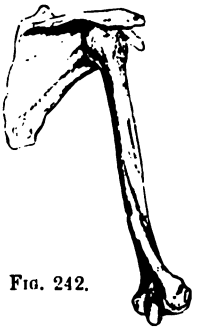


FIG. 242.

Sub-spinous

FIG. 243.

Sub-clavicular

FIGS. 240, 241, 242, 243.—Various forms of dislocation of the humerus. (Professor Flower's models.)

felt beneath and a little external to the acromion, the head is in the glenoid cavity. Occasionally a dislocation is complicated by a fracture, and an accurate diagnosis may be rendered very difficult. In such, and in all cases where there is any doubt, the position and condition of the head of bone should be ascertained by the *x* rays, and a further examination, if necessary, should be subsequently made under an anæsthetic.

The subcoracoid.—This is the most frequent variety of dislocation of the shoulder (Fig. 240). The head rests on the anterior surface of the neck of the scapula, just below the coracoid process, the groove between the head and greater tuberosity resting on the anterior margin of the glenoid cavity. The capsular ligament is lacerated, anteriorly and inferiorly, or detached from the margin of the glenoid cavity in front and below. The subscapularis is generally raised by the head of the bone from the scapula, and the supraspinatus, infraspinatus, and teres minor are tightly stretched. Sometimes these muscles are torn across at their insertion, or the greater tuberosity is detached, the muscles remaining entire. Under these circumstances the head of the bone rolls inwards so that more of it is internal to the coracoid process, a condition described by Malgaigne as a distinct variety (*intracoracoid*). The long head of the biceps is generally uninjured, whilst the short head and the coraco-brachialis and the axillary artery and brachial plexus are displaced inwards by the head of the bone. *Special signs.*—1, the head of the bone can be seen and felt in its abnormal situation; 2, the elbow projects slightly backward and away from the side; 3, the arm is generally shortened or unaltered in length; occasionally it is said to be lengthened. The truth appears to be that there are all grades between the subcoracoid as here described, in which there is undoubted shortening, and the next form, the subglenoid, in which lengthening as undoubtedly occurs.

The *subglenoid* is the next most common variety. The head rests on the inner aspect of the inferior border of the scapula, below and a little in front of the glenoid cavity (Fig. 241). The capsular ligament is ruptured below. The supraspinatus, infraspinatus, teres minor, and subscapularis may or may not be torn. The circumflex nerve is especially liable to be compressed, producing temporary or even permanent paralysis of the deltoid. The signs are similar to those of the subcoracoid, but there is greater flattening of the shoulder, more prominence of the acromion, and a more marked depression under it, and the elbow points neither backwards nor forwards, but is carried away from the side. *Special signs.*—1. Great depression of the anterior fold of the axilla; 2, presence of the head of the bone in the axilla; 3, lengthening of the arm; 4, an interval of from one to two inches between the coracoid process and the head of the bone. A very rare variety of the subglenoid dislocation, in which the arm is not only abducted but also raised so that the elbow is on a level with the head, is known as *luxatio erecta.*

The subspinous.—This variety is rare. The head rests on the dorsum of the scapula beneath the spine (Fig. 242). The capsular ligament may or may not be ruptured. The infraspinatus is generally torn up from the bone, and the subscapularis and supraspinatus are either stretched, or ruptured, according to the

amount of displacement. The teres minor is relaxed, and the long tendon of the biceps stretched or displaced from its groove. *Special signs.*—1. Great flattening of the shoulder, with a deep hollow below the coracoid; 2, slight lengthening of the arm; 3, the elbow points forwards; 4, the forearm is in front of the chest in consequence of the inward rotation of the humerus, which is close to the side; 5, the head of the bone can be felt in its abnormal situation, but not in the axilla.

The subclavicular is very rare. The head rests beneath the clavicle, internal to the coracoid process (Fig. 243). The capsule is generally extensively lacerated at its inner side. The pectoral muscles are raised by the head of the bone, which rests on the ribs either on or between the fibres of the subscapularis. The latter muscle is torn up from the subscapular fossa, but retains its connection to the humerus. The supraspinatus and infraspinatus are generally torn, or detached from the humerus, but may retain their connection to the capsular ligament. The teres minor is not torn. *Special signs.*—1, The head of the bone forms a distinct prominence below the clavicle; 2, the shaft only can be felt in the axilla; 3, the arm is pressed tightly to the chest; and 4, the elbow projects backwards.

Diagnosis.—A dislocation of the shoulder may have to be diagnosed from a fracture of the neck of the humerus, separation of the upper epiphysis, fracture of the neck of the scapula, fracture of the glenoid cavity, and from simple sprains and contusions of the joint attended with more or less paralysis of the deltoid. Attention to the general and special signs of dislocation as above given, together with the absence of crepitus and other signs of fracture, will generally make the diagnosis easy; but where the patient is very muscular, or there is much swelling, or manipulation causes excessive pain, a skiagraph should be first taken, and if this is not quite satisfactory, a thorough examination should be made under an anæsthetic. It should not be forgotten that crepitus may be simulated by effusion into the joint and sheaths of the surrounding tendons. True bony crepitus having been once felt, however, can hardly be mistaken for this.

Treatment.—The difficulty in reducing a recent dislocation consists in—1. Overcoming muscular contraction; and 2. Reintroducing the head of the bone through the hole in the capsule. In long-standing cases there are additional impediments to reduction, viz., 3. The formation of adhesions around the joint. 4. Alteration in the shape of the head of the bone; and 5. The obliteration of the old cavity. Manipulation should first be tried, if necessary, under an anæsthetic, and if this fails, extension should be made with the knee or heel in the axilla. In some long-standing cases where the above methods have failed reduction by open incision rather than the use of excessive force, as by the pulleys, may be advisable.

1. *Manipulation.*—Many methods have been devised, some of which are not unattended with danger, as the axillary artery has

Fig. 244.—Kocher's method of reducing dislocation of the shoulder. Arm abducted and rotated out.

Fig. 245.—Kocher's method of reducing dislocation of the shoulder. External rotation still kept up whilst elbow is carried across chest.

Fig. 246.—Kocher's method of reducing dislocation of shoulder. Rotation of humerus inwards.

been torn or ruptured in their use. The following will be found safe and generally effective:—

Kocher's method.—Place the patient on a chair or couch, and whilst an assistant steadies the shoulder, flex the elbow; abduct the humerus and rotate it outwards as far as possible without using

excessive force (Fig. 244), then carry the elbow across the chest (Fig. 245), keeping up the eversion, and finally rotate the humerus inwards (Fig. 246).

Single-handed method.—Place the patient on his back. Stand on the injured side facing the patient, with your pelvis or thigh against his chest, carry the affected arm across your pelvis, behind your back, to your hip which is next the patient; and hold it firmly there with your hand of that side. With the other hand grasp the dislocated shoulder and make pressure on the head of the bone with your thumb. Now slowly rotate your body away from the couch and so draw the bone into the glenoid cavity.

Another method consists in slowly abducting the arm to the level of the shoulder or above.

2. *Extension* (Fig. 247).—Place the patient on his back; seat

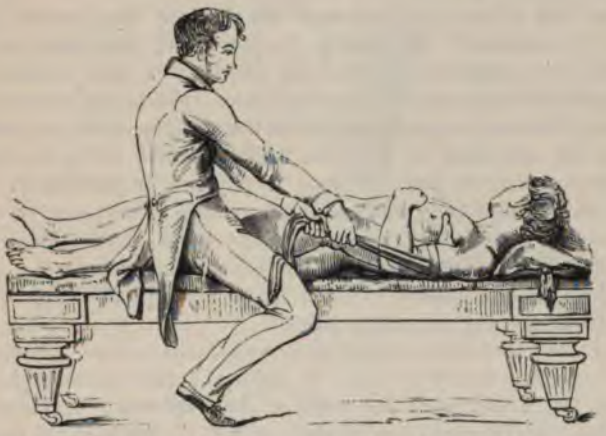


Fig. 247.—Reduction by the heel in the axilla. (Cooper's Dislocations.)

yourself on the edge of the couch; draw the arm slightly from the side; place your heel without your boot well in the axilla, and grasping the wrist make steady extension on the arm, whilst the heel fixes the scapula and presses the head of the bone outwards. The head of the bone will probably be felt after a few minutes to slip into its place with an audible snap. Should it not do so, secure a jack towel with a clove-hitch (Fig. 82) to the arm, and increase the extending force by getting an assistant to pull on it at the same time. The direction of the force may be slightly varied from time to time, and the humerus gently rotated. Where extension with the heel in the axilla fails, slowly carry the arm to a right angle with the body and extend, or raise it above the head, and again extend in this position. If still unsuccessful an anæsthetic should be given, and the head of the bone, on again

fingers and forearm may often with advantage be bandaged to prevent œdema, or better, be massaged without moving the elbow.

3. **The lower end of the humerus.**—Fractures in this situation may be divided into (*a*) transverse fracture; (*b*) separation

Fig. 259.—Skiagram of a fracture of the lower end of the humerus with displacement of the lower fragment backwards and upwards. The lower end of the upper fragment projects in front of the joint. Common form. (Taken by Dr. Hugh Walsham.)

of the epiphysis; (*c*) T-shaped fracture; (*d*) fracture of the condyles. Of these, the transverse when above the condyles, the separation of the epiphysis, and the fracture of the tip of the internal condyle, are *extracapsular;* the others involve the joint. *Cause.*—All varieties are generally the result of direct violence, such as falls upon the bent elbow.

trying manipulation or extension, will probably slip back quite easily into place.

After-treatment.—A pad should be placed in the axilla and the arm carefully bandaged to the side with the forearm across the chest and the hand on the opposite shoulder. Passive movements of the joint should be begun about the end of a week and practised once or twice daily; but the arm should be bandaged to the chest in the intervals for upwards of three weeks, and subsequently used with great caution for several months to prevent re-dislocation. especially when abducting.

Occasional ill-effects following a dislocation of the shoulder.—1. Inflammation or suppuration of the joint and ankylosis; 2. Paralysis of the deltoid or other muscles; 3. Axillary abscess; 4. Non-union of the rent in the capsule and a consequent tendency to re-dislocation on very slight violence.

How long after a dislocation of the shoulder has occurred does it admit of reduction? Sir Astley Cooper fixed the limit at three months, but cases are reported in which it is said to have been accomplished two years after the accident. It should be remembered, however, that as in unreduced dislocations a new cavity is gradually formed for the head of the bone whilst the old cavity is filled up, reduction sooner or later becomes a physical impossibility. Still, where the arm is very stiff, although reduction may not be accomplished, the range of motion in the false joint may be considerably improved by the attempt. On the other hand, where the motion is fairly free, the injury inflicted in an attempt at reduction may counterbalance any advantage gained.

Risks that may attend reduction in long-standing cases.—1. Rupture of the axillary artery or vein; 2. Injury of the brachial plexus of nerves; 3. Fracture of the neck of the humerus; 4. Fracture of the ribs; 5. Tearing open of the axilla; 6. Evulsion of the arm; and 7. Fatal shock in the old and feeble.

4. *Reduction by open incision.*—This method has been recently employed for long-standing cases where cautious attempts at reduction by manipulation and extension have failed. The advantages claimed for it are:—1. That the reduction can be accomplished without subjecting the patient to the dangers mentioned above; and 2. That it is applicable to periods later than those at which reduction by manipulation or by extension can be accomplished without undue risk. An incision is made down to the head of the bone between the pectoralis major and deltoid muscles, and the subscapularis muscle detached from its insertion into the lesser tuberosity. The long head of the biceps should be preserved as in excision of the joint. If the bone cannot now be manipulated or prised by an elevator into position the attachments of the external rotators (the supraspinatus, infraspinatus and teres minor) are in like manner detached from the greater tuberosity. The head will

now probably return into its socket unless the time that has elapsed has been sufficient for it to have been partly absorbed and the glenoid cavity filled up. When, however, the head cannot be replaced it may be excised. Passive movements ought to be begun as soon as the wound has healed.

Treatment of compound dislocation of the shoulder.—When the wound is small, the head of the bone uninjured, and the soft parts are neither much lacerated nor bruised, an attempt should be made to reduce the dislocation. If successful, the case may then be treated as a wound of the joint. When the head of the bone is much injured, it may be excised; whilst in severe and complicated cases, amputation at the shoulder-joint may become necessary.

The treatment of dislocation with fracture is often attended with much difficulty. It was formerly taught that the fracture, if possible, should be set, the arm placed in splints, and an attempt

FIG. 248.—Dislocation of the radius and ulna backwards. (Cooper's Dislocations.)

FIG. 249.—Dislocation of the radius forwards.

then made to reduce the dislocation. But this plan is not likely at all to succeed. This accident should be treated by open incision and the fragments wired. Even when exposed the head is not always easy to replace. McBurney succeeded in drawing it into the glenoid cavity by a hook inserted into a hole made by a drill. If the union cannot be satisfactorily done the head should be excised.

Treatment of recurrent dislocation.—When the humerus constantly slips out of its socket on the least muscular exertion, in consequence probably of a large unhealed rent in the capsule or separation of the rotators from the tuberosities, the injection of a few drops of chloride of zinc, 10 per cent., should be tried first; next the excision of the elliptical portion of the excessively slack capsule; and then, these measures failing, an excision of the head of the bone holds out the best prospect of relief.

Dislocation of the elbow is most frequent in the young. *Cause.*—Direct violence, or a fall on, or wrench of, the forearm or hand. *Varieties.*—A. *Both bones* (radius and ulna): 1, backwards; 2, inwards; 3, outwards; 4, forwards; and 5, radius forwards, and

ulna backwards. B. *Radius only:* 1, forwards; 2, backwards; and 3, outwards. C. *Ulna only:* 1, backwards. Of these, the dislocation of both bones backwards and of the radius forwards or backwards are the only common forms; the others are very rare and will receive but a passing notice.

Signs.—In the common form of *both bones backwards* (Fig. 248), the radius and ulna are displaced directly backwards, so that the coronoid process of the ulna rests in the olecranon fossa, and the neck of the radius on the capitellum of the humerus. The coronoid process is occasionally fractured at the same time. The anterior, and often the lateral ligaments are torn, and the brachialis anticus is tense or partly lacerated. The bones are frequently displaced slightly outwards, or inwards, as well as backwards—modifications which have been unnecessarily classed as distinct varieties. The forearm is fixed, partially flexed, and shortened. The olecranon and head of the radius form an unnatural prominence posteriorly, and are felt at a considerable distance behind the internal and external condyles respectively. The lower end of the humerus forms a broad projection *below* the crease of the bend of the elbow. In the rarer forms of *both bones inwards* or *outwards* the prominence of the opposite condyle of the humerus on one or other side is a characteristic feature. In *both bones forwards* (exceedingly rare) the forearm is lengthened, the natural prominence of the olecranon is lost, and the condyles of the humerus are very prominent. In the *ulna backwards and the radius forwards* the arm is greatly increased in its antero-posterior diameter.

In dislocation of the radius alone, whether forwards, backwards, or outwards, the head of the bone is felt to roll in its abnormal situation, in front of, behind, or external to, the external condyle on pronating and supinating the hand. The first of these forms (Fig. 249) is the most common, and in it the forearm cannot be flexed beyond a right angle, in consequence of the head of the bone striking the humerus, especially in children, in which the head is not yet fully developed, so that it is easily drawn out from the grasp of the orbicular ligament when extension is made. In slight cases of "pulled elbow" the displacement is merely a subluxation and is most easily reduced. The position of the head of the radius in the outward variety is shown in the accompanying skiagram (Fig. 250).

In dislocation of the ulna backwards the forearm is pronated and shortened on the ulnar side, and the olecranon projects backwards, but the head of the radius is felt in its normal situation.

Diagnosis.—In moderately thin subjects when seen soon after the accident, attention to the above signs will generally enable the surgeon to make a diagnosis; but in a few hours the parts become so obscured by swelling about the joint, that it may be impossible to make out the nature of the injury till it has subsided, except by the *x* rays or by examination under an anæsthetic.

In all cases of injury of the elbow the relation of the points of bone to each other should be carefully compared with those of the uninjured side, and the relative position of the olecranon to the condyles should be determined (see *Diagnosis of Fracture of the lower end of the Humerus*).

Fig. 250.—Dislocation of the radius outwards. (From a skiagram taken by Dr. Hugh Walsham.)

Treatment.—The reduction of the common form of dislocation of *both bones backwards* is generally easily accomplished in recent cases by pressing with the knee in the bend of the elbow on the upper part of the radius and ulna to disengage the coronoid process, whilst forcibly but slowly flexing the forearm. As soon as the coronoid process is freed from the olecranon fossa, the muscles generally draw the bones suddenly into position. Pressure upon

PLATE XIII.

Skiagram of a greenstick fracture of the radius and ulnar in a rickety child.
(Taken by Dr. Hugh Walsham at St. Bartholomew's Hospital.)

[*To face p.* 593.

PLATE X.

Deformity resulting from unreduced dislocation of the head of the radius.
(From a skiagram by Dr. Hugh Walsham.)

[*To face p.* 580.

and outwards, instead of downwards, forwards and inwards. This, according to Mr. R. W. Smith, is due to the action of the supinator

Fig. 264.—Skiagram of fracture of the lower end of the radius (Colles' fracture). The characteristic abduction of the hand was not present. (Taken by Dr. Hugh Walsham.)

longus, the extensors of the thumb, and the radial extensors of the carpus. By others it is believed to be due to the impaction of the

Dislocation of the wrist is a very rare accident as compared to fracture of the lower end of the radius. In the dislocation backwards, the carpus forms a projection on the dorsal surface of the wrist, whilst the ends of the radius and ulna project on the palmar surface. It resembles Colles' fracture, which was formerly confused with it. In the dislocation the styloid processes of the radius and ulna are on the normal level, and are nearer the knuckles than is natural, and there is no crepitus. *Treatment.*—Reduction is easily effected by making extension on the hand and pressing upon the displaced bones. The forearm and hand should then be secured to a splint, and passive movements begun early to prevent stiffness.

Dislocation of the lower end of the radius from the ulna may be produced by a violent twist of the hand. When the twist is in the direction of pronation, the radius is displaced forward; when of supination, backwards. The former is the more common. The hand accompanies the radius, and the styloid process of the ulna projects prominently in the opposite direction and has been sometimes forced through the skin. *Treatment.*—Whilst making extension from the hand, manipulate the bone into position and retain it there by a compress and splint.

FIG. 251.—Dislocation of the thumb backwards at the metacarpo-phalangeal joint. (After Agnew.)

Dislocations of the carpal and metacarpal bones are very rare. Their diagnosis is usually obvious.

Dislocation of the metacarpal bone of the thumb from the trapezium may occur in a backward or forward direction, and is easily reduced by extension or pressure.

The phalanges of the fingers may be dislocated backwards or forwards. Reduction is easily effected by extension and manipulation.

Dislocation of the first phalanx of the thumb from the metacarpal bone is of more importance. The phalanx is nearly always displaced backwards; the shortening of the thumb and the projections of the base of the phalanx and head of the metacarpal bone serve for its diagnosis. Reduction is often very difficult; this is usually ascribed to the head of the metacarpal bone being forced between the two insertions of the flexor brevis pollicis by which its neck is tightly embraced (Fig. 251). The hindrance to reduction, however, would appear chiefly to depend upon the fact that the sesamoid bones with the glenoid ligament connecting them are carried back with the phalanx over the head of the metacarpal bone, and so prevent the articular surfaces of the bones being brought into contact. *Treatment.*—Press the metacarpal bone well into the palm of the hand to relax

the flexor brevis pollicis, and bend back the first phalanx on the metacarpal bone until the extremity of the thumb points towards the wrist, thus forcing the base of the phalanx wedge-wise between the sesamoid bones and the two insertions of the short flexor. Next flex the phalanx while an assistant, by placing his thumb behind its base, prevents it slipping back. The head of the metacarpal bone will now probably slide into its place between the two sesamoid bones, which are forced apart by the wedge-like action of the base of the phalanx. Reduction may sometimes be accomplished by extension, *e.g.*, by the clove-hitch made of a strip of soft leather, or, if at hand, by the Indian puzzle toy or the American forceps—a method, however, less scientific than that of manipulation, and one which seldom succeeds if the other fails. These means not proving successful, it is usually advised that the insertion of the flexor brevis pollicis should be subcutaneously divided. Sir George Humphry, however, recommended an incision over the sesamoid bones and the introduction of a hook to hitch the sesamoid bones over the head of the metacarpal. Mr. Hutchinson advises the subcutaneous division of the glenoid ligament by means of a tenotome introduced dorsally behind the projecting base of the phalanx. As a better resource, the joint may be cut down upon, the glenoid ligament and any other bands resisting reduction divided and the bone replaced. In old standing cases the joint may have to be excised, but in such it is perhaps better left alone, as very fair movement will, as a rule, in time be gained.

Fractures of the Upper Extremity.

Fractures of the clavicle are divided into fractures of—1, the *shaft*; 2, the *acromial end*; and 3, the *sternal end*.

I. *The shaft* may be fractured by direct violence, or, as is more commonly the case, by indirect violence, such as a fall upon the arm or shoulder; more rarely by muscular action. *Situations.*—When the result of indirect violence or muscular action, the bone is generally broken near its centre—its weakest part. When due to direct violence, the bone will break wherever the force is applied. *Nature of the displacement.*—The inner fragment, although it appears raised in consequence of the depression of the outer, is not displaced, being held in position by the sterno-mastoid and the rhomboid ligament; the outer fragment is drawn downwards, forwards and inwards by the weight of the arm and the contraction of the pectoral muscles. The *signs* in an adult are usually very evident. The inner fragment projects prominently under the skin; the shoulder droops forwards and downwards; the patient usually supports his elbow with the sound hand whilst he inclines his head to the fractured side to relax the sterno-mastoid. In a fat child, however, especially when the fracture is of the greenstick variety (Fig. 252), which it often is in

children, the signs are less evident; indeed, surgical aid may not be sought until the mother's attention is called to the part by the presence of a lump formed by the ensheathing callus. Union generally occurs in about three weeks in children and five in adults. *Treatment.*—The fracture is easily reduced by drawing

Fig. 252.—Greenstick fracture of the clavicle. (Holmes' system.)

back the shoulders, or by placing the patient in the recumbent posture; but it is very difficult to maintain the fragments in apposition. Hence the numerous bandages and apparatus that have been from time to time employed. Where it is important to avoid deformity, rest on the back for a fortnight is essential; otherwise the patient may be allowed to get about with his arm bandaged to the side, and the parts kept as much as possible in apposition by bandaging or strapping. Of the many plans the following may be tried.

a. Sayre's method.—Take three pieces of adhesive strapping about

Fig. 253. Fig. 254. Fig. 255.

Figs. 253, 254, 255.—Sayre's method of treating fractured clavicle. (After Agnew.)

three inches and a half wide, and long enough to surround the arm and afterwards the body. Stitch one piece, with the adhesive surface outside, loosely round the arm on the injured side at the insertion of the deltoid muscle. Draw the arm forcibly backwards

After reducing the fracture as thoroughly as possible, and if necessary under an anæsthetic, apply two ordinary forearm splints, taking care that the anterior one does not reach beyond the heads of the metacarpal bones, and place a pad beneath the wrist to restore the lost concavity of the front of the radius. Practise passive movements of the fingers from the third day, as in this form of fracture the tendons, where they cross the back of the radius, the seat of fracture, are apt to become adherent to their grooves. This is the almost invariable method of treating Colles' fracture at St. Bartholomew's Hospital, and is attended with excellent results. If preferred, Carr's (Fig. 265) or Gordon's (Fig. 267) splints may be used. After the splints are applied, a skiagraph should be taken to make sure that the fracture has been properly reduced. The pistol-shaped splint introduced by Nélaton, and justly condemned by Sir James Paget as so frequent a cause of stiff wrist and fingers, should on no account be used. Remove the splints in two or three weeks, and employ shampooing, friction with stimulating liniments, etc., till any stiffness of the joint or fingers that remains has disappeared.

Fig. 266.—Separation of the lower epiphysis of the radius from a lad aged 16 years. (St. Bartholomew's Hospital Museum, No. 758 *b*.)

Separation of the lower epiphysis (Fig. 266) may occur in young subjects, and resembles Colles' fracture, and like the latter, has to

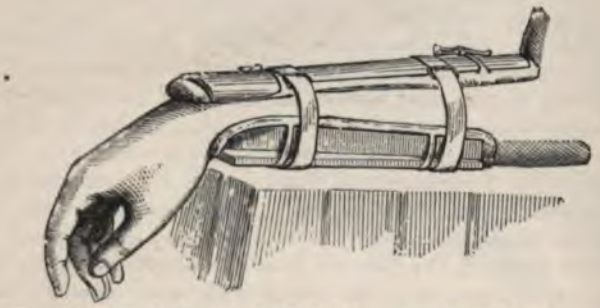


Fig. 267.—Gordon's splint for Colles' fracture. (Gordon's Fractures.)

be distinguished from a backward dislocation of the wrist. The lower end is not comminuted, nor is the wrist-joint involved. Bony union occurs, hence the lower end of the radius ceases to grow, and the hand is pushed over to the radial side by the growth of the ulna, causing much deformity if the accident occurs in childhood.

The ulna.—Fractures of the ulna may be divided into fracture of—1, the olecranon; 2, the coronoid process; and 3, the shaft.

1. *The olecranon* may be fractured in a transverse or oblique direction. The elbow-joint is always involved, except when the fracture is through the tip of the process only. *Cause.*—Direct violence, as a fall on the point of the elbow, or violent action of the triceps muscle. *Nature of the displacement* (Fig. 268).—The detached fragment is usually widely separated from the rest of the bone by the triceps; but when the periosteum and tendinous expansion of the triceps covering the olecranon is not torn, and the fracture is very oblique, little or no displacement occurs. *Signs.*—Swelling from effusion of blood, and later of serum, into the joint; inability, as a rule, to extend the arm; and, generally, the presence of a gap between the fragments. *Method of union.*—Osseous only when the fragments remain in apposition, otherwise fibrous.

Treatment.—This is on lines similar to that of the patella. When there is separation the fragments should be wired together at once

Fig. 268.—Fracture of olecranon. (Liston's Surgery.)

through a curved incision, so that the line of the incision shall not be immediately over the wire; passive movement with massage and active movement follow as soon as possible. If wiring be not resorted to, movements should be encouraged from the first to avoid stiffness and weakness of the triceps, the arm meanwhile simply resting on a cushion, with cold lotions applied to the elbow. Fixation of the elbow on a splint, whether at a right angle or, worse still, in extension, is useless. Only fibrous union results, and the elbow is likely to become stiff and the muscles weak.

2. *The coronoid process of the ulna*, except in dislocation of the ulna and radius backwards, is rarely fractured. It is said at times to occur from violent contraction of the brachialis anticus muscle. *Signs.*—When fracture of the coronoid is present in dislocation of the radius and ulna backwards, the dislocation is readily reduced, but immediately returns on relaxing the extending force. When fracture of the coronoid is not present, the dislocation is more difficult to reduce; but when once reduced, has no tendency to recur. *Treatment.*—After reducing the dislocation, place the arm in a

flexed position on an inside angular splint. Employ passive movements early.

3. *The shaft of the ulna* is occasionally fractured without implication of the radius. *Cause.*—Direct violence. *Nature of the displacement.*—The upper fragment is not displaced, being held in position by its hinge-shaped articulation with the humerus. The lower fragment is drawn towards the radius by the pronator quadratus. *Signs.*—It is readily detected by running the finger along the prominent posterior border of the bone, when a gap or irregularity is felt, and by crepitus on movement. *Treatment.*—Similar to that of fracture of the radius.

The carpus, metacarpus and phalanges.—Fractures of these bones require no special mention. They may be diagnosed by the deformity and crepitus, or if obscured by swelling, by examining with the *x* rays (Plate XV.). Rest for a few days on a splint, followed by passive movements to prevent stiffness, is all that is generally necessary.

INJURIES OF THE LOWER EXTREMITY.

Bruises or contusions, burns, scalds, and frost-bites of the lower extremity call for no special mention beyond that bruises about the hip and ankle may be mistaken for fracture, and that a contusion of the limb may be so severe at times as to terminate in gangrene.

Sprains of the ankle and knee are very common. Pain, inability to bear any weight on the limb, effusion into the joint or the sheaths of the surrounding tendons, and later, ecchymosis of the skin, are the usual signs. A sprain of the ankle, when there is much swelling, is often difficult and sometimes impossible, without the aid of the *x* rays, to diagnose from a fracture, and should then be treated as such. For an ordinary sprain, if seen *before* the swelling has taken place, the foot and leg should be firmly bandaged or placed in plaster of Paris to check effusion. After keeping the limb raised for a day or two the plaster is removed, the limb massaged and use encouraged. When the swelling *is already present*, absolute rest should be enjoined, and cold or evaporating lotions, a wet bandage or hot fomentations should be applied. When the swelling has subsided, then shampooing and passive movements are employed if any stiffness be left. Some surgeons advise massage from the first. Only when the ankle is very weak during exercise should a plaster or poroplastic splint be employed. Adhesions due to excessive fixation must be broken down under an anæsthetic, and then massage and movement kept up.

Rupture of muscles and tendons, either as the result of external violence or of sudden and spasmodic contraction of the muscle, is not infrequent in the lower limbs. Rupture of the *plantaris* or *Achilles tendon* usually happens in men beyond the middle period of life without any evident cause. It is attended with

PLATE XV.

Fracture of the second and third metacarpal bones. (From a skiagram taken by Dr. Hugh Walsham.)

[*To face p.* 598.

a distinct snap, and a feeling as if the part had been struck, followed by pain, and sometimes by ecchymosis, and by inability to raise the heel. *Treatment.*—A plaster-of-Paris bandage should be applied with the foot in the extended position to approximate the ends of the ruptured tendon. If a heel is made to the plaster case, the patient need not lay up for more than a few days. The plaster case should be worn for two or three weeks.

The *adductor muscles* may be ruptured in riding. Rest must be enjoined from this exercise. The *rectus* and *vasti* are frequently partly torn at football, especially when out of training. A gap appears on putting the muscle into action, and the leg is much weakened. When this is the case the ends of the rectus should be sutured together. The *quadriceps extensor* may be ruptured close to the patella as an exceptional variation to the fracture of that bone. An old man should be encouraged to use the limb; in a young man an extensive separation should be united. The *ligamentum patellæ* may be partly torn or stretched, and may be treated as described under *Dislocation of the patella.*

Wounds in the groin, thigh, and popliteal space are important from the liability of arteries (pp. 270, 421) and nerves (pp. 280, 288) to be involved.

Dislocations of the Lower Extremity.

Dislocation of the hip.—This injury is much less common than dislocation of the shoulder, a fact readily explained by the strength of the capsular ligament, the depth of the acetabulum, and the powerful muscles by which the joint is surrounded. It occurs, however, more frequently than might be expected, owing to the powerful leverage which, from the great strength of the femur and length of the leg, is brought to bear upon the joint in falls upon the knee and foot with the limb extended and abducted. Dislocation therefore, as might be inferred, is more common in the young and strong; fracture of the neck of the femur in the old and feeble. *Cause.*—Dislocation of the hip, whatever form it may take, generally occurs when the limb is abducted. In this position the head of the bone presses upon the inner and lower part of the capsule, its weakest part, and if any sudden or great force is now applied to the other end of the lever, the head of the bone may be forced through the capsule at this spot into the obturator foramen. Here it may remain, or if at the time of the accident the limb is flexed and rotated inwards as well as abducted, it may be carried round the outer margin of the acetabulum on to the dorsum ilii; or, if the limb is extended and rotated outwards as well as abducted, round the inner margin on to the pubes. In rare instances it would appear to occur during forced adduction of the limb, the head of the bone being then driven directly backwards on to the dorsum ilii. In such a case,

however, the rim of the acetabulum is generally, though not always, splintered off at the same time.

The Y, *or ilio-femoral ligament* plays so important a part in dislocation of the hip that its attachments should be briefly considered before studying the varieties of this dislocation. It consists of a thickening of the front of the capsular ligament, and is attached above to the anterior inferior spine of the ilium, and then divides into two branches like the letter Y inverted. The outer branch is inserted into the upper part of the anterior inter-trochanteric ridge; the inner branch into the lower part of that ridge. It is exceedingly strong, and will bear a breaking strain of from 250 to 750 pounds. Both branches limit extension; the outer branch rotation outwards as well. The whole ligament, therefore, is tense during extension and outward rotation of the limb; relaxed during flexion and rotation inwards.

Varieties.—Dislocations of the hip are divided by Bigelow into the *regular*, in which one or both branches of the Y ligament are intact, and the *irregular*, in which both branches are ruptured. In the former the signs are constant, as the untorn branch of the Y ligament compels the bone to take a certain definite position. In the irregular the signs vary, as both branches of the Y being ruptured, the control which it exercises over the position of the bone is lost. Our attention here will only be directed to the regular dislocations. Of these Bigelow describes seven, the first four of which are commonly known as the *classical dislocations of Sir Astley Cooper*.

Cooper's Classification.		Bigelow's Classification.	
		A. Regular. *One or both branches of* Y *entire.*	
Dislocation on to the dorsum ilii	=	1. Dorsal	Both branches of Y entire.
Dislocation into the sciatic notch	=	2. Dorsal below the tendon	
Dislocation into the obturator foramen	=	3. Thyroid and downwards	
Dislocation on to the pubes	=	4. Pubic and subspinous	
		5. Anterior oblique	
		6. Supraspinous	Outer branch of Y ruptured.
		7. Everted dorsal	
		B. Irregular. *Both branches of* Y *ruptured.*	

1. *Dislocation on to the dorsum ilii* (*the dorsal of Bigelow*).—This is the most common form of dislocation of the hip. The head of the bone is thrown upwards and backwards on to the dorsum of the ilium, the articular surface of the head looking backwards, and the great trochanter forwards. The capsular ligament is generally ruptured at its lower and inner part, sometimes posteriorly, and the round ligament is usually torn. The Y ligament is uninjured, the external branch preventing eversion. The glutei muscles are raised from the ilium by the head of the bone, which is always situated above the tendon of the obturator internus. The other external rotators have been found variously lacerated or torn from

FIG. 269.—Dislocation on dorsum ilii.

FIG. 270.—Dislocation into sciatic notch.

(Cooper's Dislocations.)

(*Note.*—These classical figures and those on p. 603 are depicted upright the better to show the deformity. It is not intended that the patient should be examined in any other position than lying down.)

their attachments. *Signs* (Fig. 269).—The limb is slightly flexed, adducted, rotated inwards, and shortened, so that the lower end of the femur crosses the lower third of the opposite thigh, and the great toe rests on the instep of the opposite foot. The head of the bone, at least in thin subjects, can be felt in its abnormal situation on attempting rotation of the limb. The great trochanter is above

a line drawn from the anterior superior iliac spine to the most prominent part of the tuberosity of the ischium (*Nélaton's line*) (Fig. 271); and the distance from the top of the great trochanter to a line drawn horizontally round the pelvis on a level with the

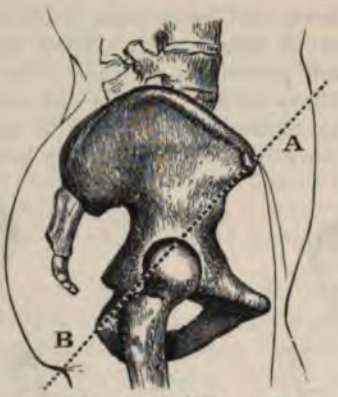


FIG. 271.—A—B, Nélaton's line.

anterior superior iliac spines (*Bryant's line*) is less on the injured than on the sound side.

2. *Dislocation into the sciatic notch* (*the dorsal below the tendon of Bigelow*).—The head of the bone escapes below the tendon of the

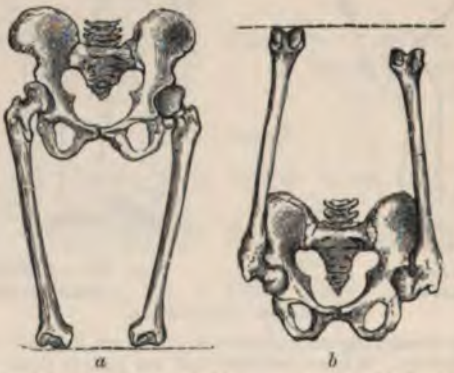


FIG. 272.—Sciatic dislocation of the left hip. *a*, shows slight shortening in extended position of limb; *b*, shows marked shortening in flexed position. (After Dawson, of Ohio.)

obturator internus, and then ascends behind it on to the surface of the ilium just in front of the sciatic notch, or on the pyriformis as it emerges from the notch. The head looks backwards and the great trochanter forwards, eversion being prevented by the

outer branch of the Y ligament. The tendon of the obturator internus winds over the neck of the femur, and is therefore the great obstacle to reduction. The capsule is generally torn below, the round ligament ruptured, the gluteus maximus raised by the head of the bone, and one or more of the external rotators are usually torn. The *Signs* (Fig. 270) are very similar to those of the former variety; but the flexion, adduction, and rotation inwards are less pronounced. The lower end of the femur crosses the

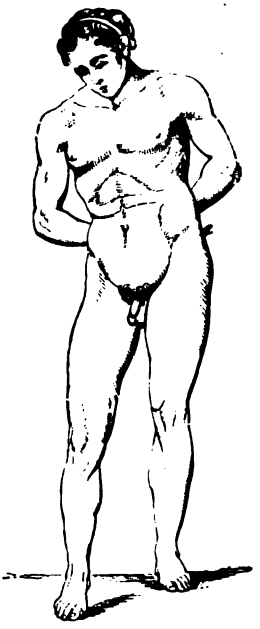


FIG. 273.—Dislocation into obturator foramen.

FIG. 274.—Dislocation on the pubes.

(Cooper's Dislocations.)

(See note on p. 601.)

opposite knee, and the great toe rests on that of the opposite foot. Shortening with the limb extended is much less than in the former variety; but with the limb flexed it is much greater. This is shown in the accompanying diagram (Fig. 272), and depends upon the fact that in the dislocation on to the dorsum ilii the head of the bone in extension lies above the acetabulum, and when flexed at a right angle to the body on the same level as the acetabulum; whereas in the sciatic dislocation the head of the bone in extension is almost on the same level as the acetabulum, but when

flexed at a right angle to the body lies considerably behind the acetabulum.

3. *Dislocation into the obturator foramen (the thyroid and downwards of Bigelow).*—The head is displaced downwards on to the obturator externus, where it lies suspended by the Y ligament, and may remain either just below the acetabulum, or be carried slightly inwards towards the perineum or outwards towards the tuberosity of the ischium. The head of the bone generally looks slightly inwards, and the trochanter outwards. The capsule and round ligament are ruptured, the former at its lower and inner part. The glutei, pyriformis, psoas and iliacus, obturator externus, pectineus, and the abductor brevis are stretched or sometimes torn. *Signs* (Fig. 274).—In the more common form, viz. that in which the head is displaced downwards and a little inwards, the limb is apparently *lengthened*, due to the lowering of the pelvis on that side, but is really shortened about half an inch or so. It is also abducted and slightly flexed, whilst the body is bent forwards to relax the psoas and iliacus, and as there is usually some external rotation, the toes point slightly outwards. The nearer the head of the bone approaches the perineum the more plainly can it be felt, and the more eversion and abduction will there be; conversely, the nearer it approaches the tuberosity of the ischium the greater its inversion and adduction; whilst when it is displaced directly downwards there will be neither eversion nor inversion, adduction nor abduction, but marked flexion.

4. *Dislocation on to the pubes (the pubic and subspinous of Bigelow).*—The head of the bone is thrown forwards and rests below Poupart's ligament, either upon the ramus of the pubes (*pubic*) or upon the pectineal eminence just in front of the anterior inferior spine (*subspinous*). The head looks forwards and the trochanter backwards. The capsule is generally torn below, and the round ligament ruptured. The Y ligament is entire and produces the eversion of the limb characteristic of this variety. The psoas and iliacus, with the anterior crural nerve between them, are generally stretched tightly over the head of the bone. The femoral vessels are displaced to its inner side. *Signs* (Fig. 274).—The limb is slightly shortened, flexed, abducted, and rotated outwards; and the head of the bone can be plainly felt in its new situation. There is flattening over the hip-joint.

The *anterior oblique*, *supraspinous*, and *everted dorsal*, the three remaining regular dislocations of Bigelow, are too rare to be described here. They can readily be produced, however, on the dead body. Thus the ordinary dorsal dislocation can be converted into the *anterior oblique* by carrying the leg across the symphysis, forcibly everting the thigh, and bringing it down across the lower third of the opposite thigh, in which position it becomes firmly locked. If now the thigh is forced into the perpendicular position,

the outer branch of the Y ligament will be ruptured and the *supra-spinous* variety produced. This variety in its turn can be converted into the *everted dorsal* by circumducting the extended limb inwards and then everting it.

Treatment.—Reduction may be effected by: 1, manipulation; 2, traction with the limb in the flexed position; 3, traction with the limb in the extended position. Of these methods the first and the second are the most scientific, and when their principles are understood and they are rightly applied, they are usually the most successful. Recent dorsal dislocations should always be reduced by the first or second method, aided if need be by an anæsthetic; and these methods will often succeed in reducing cases of long standing after traction in the extended position, even with the pulleys, has failed. In long-standing cases, should manipulation fail, reduction should be made by 4, open incision.

1. *Reduction by manipulation* consists in relaxing the Y ligament, the chief obstacle to reduction, and then by means of various movements of rotation, circumduction and extension applicable to each particular variety of dislocation, in making the head of the bone retrace its steps round the margin of the acetabulum, and finally re-enter the acetabulum through the hole in the capsule by which it escaped. To do this it is necessary to know in what direction the head of the bone looks in any particular position of the limb—a point easily determined by remembering that the articular surface of the head looks very nearly in the same direction as the internal condyle. It must be further remembered that by rotation is meant the rolling of the femur on its own axis; that in outward rotation the anterior surface of the patella is rolled outwards, and in inward rotation inwards; that by circumduction is meant the revolving of the femur round the axis of its head, and that in this movement the anterior surface of the patella always looks to the front. During the manipulation the patient should be placed upon his back upon the floor, while the surgeon with one hand should grasp the ankle, and with the other the thigh or leg, and put the limb through the several movements required for the kind of dislocation. An assistant, if necessary, should fix the pelvis. For the dislocation on the *dorsum ilii* and into the *sciatic notch* the movements are practically the same (Fig. 275). The limb should be flexed and slightly adducted to disengage the head from behind the acetabulum and then abducted, rotated outwards and brought down parallel to the sound limb. These movements are tersely described by Bigelow in the words "lift up," "bend out," "roll out," *i.e.*, lift up or flex—bend out or abduct—roll out or rotate outwards. The head is thus compelled to revolve round a centre formed by the great trochanter, which is held in position by the outer branch of the Y ligament. In the *thyroid* (Fig. 276) the thigh should be flexed and slightly abducted, then rotated forcibly inwards and adducted, and brought

down parallel to the sound thigh. The head is thus made to retrace its steps towards, and re-enter the acetabulum, the Y ligament being wound up, as it were, and so put on the stretch. In the *pubic* the reduction is said to be accomplished in a manner similar to that employed for the thyroid. In a pubic dislocation recently under the care of one of us (Walsham) manipulation failed, although practised several times, the head in each instance passing into the thyroid foramen. On gentle traction, however, downwards and outwards the head was reduced with ease. A present and a former colleague have each had a similar experience to ours.

2. *Reductions by traction with the limb in the flexed position.*—The flexion of the limb has for its aim the relaxing of the Y ligament

FIG. 275.—Method of reducing the dorsal and sciatic dislocations of the hip by manipulation.

FIG. 276.—Method of reducing the pubic and thyroid dislocations of the hip by manipulation.

(After Bigelow.)

and other ligaments and tendons that impede reduction, and then drawing the head of the bone directly into its socket. In the *dorsal* dislocation the thigh should be flexed at a right angle to the body, and traction then made in an upward direction, slightly adducting and rotating inwards to disengage the head from behind the acetabulum. Counter-pressure may be made, if necessary, by the surgeon placing his unbooted foot on the anterior iliac spine whilst drawing or jerking the limb upwards. If on flexion it is found that the limb cannot be abducted beyond the perpendicular with the body, the hole in the capsule is probably too small to allow of the head being replaced. It may readily be enlarged by circumducting the flexed thigh outwards across the abdomen. The pulleys were used in former days, the patient then being laid on his sound side and counter-extension applied to the pelvis by a leather band secured to the wall; or the patient was placed on his back, the pelvis secured

to the floor, and the pulleys attached to a staple in the ceiling. In the *sciatic* the same manipulation should be adopted, as the flexion frees the head of the bone from the tendon of the obturator internus which winds round its neck, and together with the Y ligament, which is also relaxed by flexion, is the chief obstacle to reduction. In the *thyroid* the limb should be flexed and abducted, and the head of the bone drawn towards the socket, counter-pressure being made, if required, by the unbooted foot on the pelvis. In the *pubic* the limb should be flexed on the pelvis, whilst the head is drawn down towards the acetabulum by a jack-towel passed round the upper third of the thigh. At the same time the limb should be rotated slightly inwards.

3. *Reduction by forcible traction with the limb in the extended position* is the method recommended by Sir Astley Cooper, but is one which is now seldom used. It had for its object the drawing of the head of the femur directly into the acetabulum by main force,

Fig. 277.—Reduction of dorsal dislocation by pulleys in extended position. (Cooper's Dislocations.)

rupturing any ligaments, muscles, or tendons that offered impediment. The extending force was made in the line of the dislocated femur, generally by means of the pulleys, which were usually secured to the lower third of the thigh by a padded leather band, counter-extension being made simultaneously, and in the same straight line as the extension, by fixing the pelvis by means of a perineal band, secured by suitable straps to a staple in the wall or floor. The patient was placed on a low couch or on a mattress on the floor. The line of extension and counter-extension differed according to the form of dislocation. Thus:—In the *dorsal* (Fig. 277), extension was made across the lower third of the sound thigh, the pulleys being fixed to a staple in the wall a few feet from the foot of the couch above the level of the body, and the counter-extending band to a staple in the floor near the head of the couch. In the *sciatic* the extension was made in a nearly similar direction, save that the thigh was more flexed. In the *thyroid*, extension was made in an upward and outward direction, by means of a perineal band passed round the upper part of the dislocated thigh and attached to pulleys

fixed to a staple in the wall on the injured side. Counter-extension was made by a band passed round the pelvis and secured to a staple in the floor on the sound side. The ankle, in the meantime, was drawn towards the mesial line of the body by the surgeon's hand passed behind the sound limb. The line of extension and counter-extension here ran obliquely across the body. In the *pubic*, extension was made downwards and outwards by pulleys attached to a staple in the floor, counter-extension being made by the perineal band, which was carried upwards and inwards across the opposite shoulder, and attached to a staple in the wall. After the extension had been applied some time the head of the bone was lifted over the edge of the acetabulum by a jack-towel, the thigh, if necessary, being rotated inwards at the same time.

4. But all this extension by pulleys has been superseded by *reduction by open incision*, which has of late been practised successfully in cases of long standing where manipulation or gentle extension have failed. The head of the bone having been exposed it is freed from fibrous bands and adhesions, the acetabulum is cleared of any fibrous tissue that may be found filling it, and the head of the bone replaced. Movements are started as soon as the wound has healed.

The patella may be dislocated outwards, inwards, upwards, and edgeways. The outward dislocation is the most common; the upward variety can only occur when the ligament patellæ has been ruptured or divided. The outward and inward varieties may be complete or incomplete. In the dislocation edgeways, which is very rare, the patella rests vertically on one edge between the condyles, either the outer or the inner edge looking forwards, but most commonly the former. *Cause.*—Muscular action, or a blow on the outer or inner edge of the bone. Knock-knee predisposes to the outward dislocation, bow-leg to the inward. The *signs* are obvious, the position of the patella indicating the nature of the accident. *Treatment.*—With the patient anæsthetised, the thigh should be flexed on the abdomen to relax the quadriceps extensor muscle; and the leg, for the same purpose, extended on the thigh. In the outward and inward dislocation, pressure should now be made on the edge of the patella that is further from the centre of the joint so as to raise the opposite edge and tilt it over the condyle, when it is at once drawn into place by the action of its muscles. In the edgeways variety, pressure should be made with the thumbs in opposite directions on the upper and lower margin of the dislocated bone, this manipulation being aided by suddenly and forcibly flexing the knee, and then, if necessary, by extending it. Reduction, though generally easy, is sometimes attended with great difficulty, and has occasionally been found impossible, even after subcutaneous division of ligaments and tendons. Effusion into the joint generally follows, and should be treated in the usual way. After reduction the joint should be placed

on a back splint or in plaster of Paris, and a knee-cap subsequently worn, or the knock-knee, if present, cured to prevent a recurrence of the dislocation.

Partial dislocation of the patella, the result of an elongated patellar ligament, sometimes occurs. The elongation of the ligament allows the patella to be placed on the femur when the knee is flexed so that its anterior surface looks directly upwards. As a consequence of the elongation of the ligament, the patella from time to time is apt to slip suddenly over one or other condyle, causing the patient to fall. In three cases Walsham has succeeded in curing the condition by transplanting the tubercle of the tibia lower down the shaft of the bone for half an inch to an inch according to the amount of elongation of the ligament. The method of transplanting the tubercle will be understood by referring to

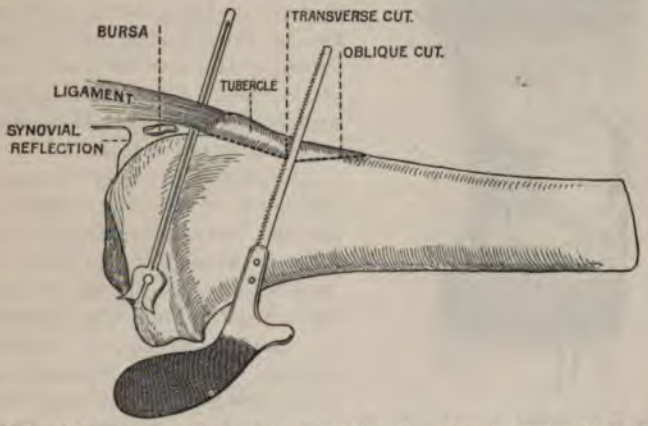


FIG. 278.— Walsham's method of transplanting the tubercle of the tibia for an elongated patella ligament.

Fig. 278. The tubercle is fixed in its new situation by an ivory peg.

The knee.—Dislocation of the knee is exceedingly rare. It may occur in a forward, backward, inward, and outward direction, and in any case may be complete or incomplete. *Cause.*—Usually great violence, as a severe wrench or twist of the joint. Five cases of complete dislocation forwards occurred simultaneously owing to a cage falling to the bottom of a mine. Two men were caught and whirled round by machinery, whilst their legs struck a wall; both had a double complete dislocation, the right forwards the left backwards. A carpenter has suffered a lateral dislocation by slipping between the joists of an unboarded floor. *Signs.*—In the lateral dislocations, which are generally incomplete, a projection caused by the condyles of the femur on the one side, with a depression below, and a

projection of the tibia, or of the fibula, as the case may be, on the opposite side, with a depression above, at once show the nature of the injury. In the antero-posterior varieties, which are generally complete, there is great shortening and deformity of the limb; the head of the tibia in the forward dislocation projects anteriorly; whilst in the backward it can be felt in the ham. In the former there is generally considerable swelling and congestion, and often pain in the limb below the knee, from pressure of the condyles of the femur on the popliteal vessels and nerves. *Treatment.*—Reduction, as a rule, is easily accomplished by extension, combined with manipulation and pressure in the direction indicated by the variety of the dislocation. The limb should then be placed on a back splint, and an ice-bag applied to the knee, passive movements being begun at the end of two or three weeks, and a knee-cap subsequently worn for twelve months at the least. Compound dislocations usually call for amputation when the popliteal artery is torn.

FIG. 279.—Splint for retaining in place a dislocated semilunar cartilage. The mechanism limits the movement of the joint to flexion and extension, all rotatory movement being prevented.

Dislocation of one of the semilunar cartilages of the knee, usually the internal, may occur from a sudden twist or wrench of the joint during semi-flexion. In miners it occurs in extending the knee after kneeling in a cramped position; the internal or external semilunar cartilage is caught and nipped across between the joint surfaces (Mayo Robson). The accident is attended with sudden and severe pain, a "locking" of the joint usually in a bent position, and the presence of a hollow, sometimes of a projection over the site of the semilunar cartilage. There is at first commonly some effusion into the joint. In chronic cases the patient may be able to displace and replace the cartilage at will by twisting his knee. The condition may closely simulate a loose body in the joint or a nipped synovial fringe, but the above signs will generally suffice to distinguish it. The diagnosis is, however, sometimes difficult unless the patient is seen at the time the cartilage is displaced. *Treatment.*—To replace the cartilage, flex the thigh on the abdomen and the leg on the thigh, and rotate the leg outwards; then manipulate the cartilage with the fingers and suddenly extend the leg, at the same time rotating it outwards. If not successful, give the patient an anæsthetic and repeat the procedure. To prevent a recurrence

the movements of the joint should be limited to flexion and extension by means of a special form of splint (Fig. 279), which should be worn for a year or longer. In intractable cases in which, notwithstanding the use of the above instrument, the cartilage is constantly being dislocated and recurrent attacks of synovitis set up, the joint should be opened through a vertical incision at the inner side, and the cartilage removed. This is best done by passing a hook under the cartilage and then shaving it off from the bone at both ends. It is important to take away as much as possible of the anterior end of the cartilage, or the symptoms may recur. Before the capsule is opened all hæmorrhage should be stopped, and at the end of the operation the synovial membrane and capsule should be accurately closed by fine silk or kangaroo-tail tendon sutures. The strictest precautions should be taken to prevent inflammation and sepsis. Thus the limb should be placed on a splint a few days before the operation, and the skin most carefully asepticised. After the operation the splint should be continued for a week or fortnight, and passive movements and massage then employed till free movement is attained.

The ankle.—The astragalus, together with the rest of the bones of the foot may be dislocated from the socket formed for it by the tibia and fibula, in an outward, inward, backward, forward, or upward direction (Fig. 295). All five varieties are generally complicated by fracture of the fibula, or of the internal malleolus. The *outward* and *inward* varieties will be described under the head of *Fracture of the Fibula* (see p. 627). The *backward* and *forward* varieties are rare; the latter especially so. In the former (Fig. 280), the astragalus is either partially or completely driven backwards from its socket, carrying with it, of course, the other bones of the foot, so that the foot appears shortened, the heel prominent, and the tendo Achillis tense. In the *forward* variety the astragalus is generally forced only partially from between the malleoli, and the foot appears lengthened, the heel less prominent than natural, and the tendo Achillis relaxed. In the *upward* variety the tibia and fibula are torn asunder, and the astragalus is forced upwards between them. The ankle appears widened, the malleoli are almost in contact with the ground, and all motion at the ankle-joint is lost. *Treatment.*—The leg having been flexed and the foot extended to relax the calf-muscles, make extension on the foot whilst an assistant holds the thigh, and then manipulate the bones into position. If necessary, give an anæsthetic, and cut the tendo Achillis. Place the foot and leg on a back splint, or, if preferred, on a Cline's or Dupuytren's splint.

Compound dislocation of the ankle.—In young and healthy subjects an attempt should be made to save the foot, unless the main vessels are torn, or there is much comminution of the bones, or extensive laceration of the soft parts, when amputation is the safer course. Resection of the bones, however, may in some instances be under-

taken with advantage, but each case must be judged on its merits, and the indications for the resection cannot be discussed here.

The astragalus may be dislocated from the tibia and fibula above and from the os calcis and scaphoid below and in front, in a forward, backward, inward or outward direction; whilst very rarely it may be rotated on its own axis either vertically or horizontally. The forward dislocation, which is generally produced by a wrench of the extended foot, is the most common, the bone in this variety usually inclining either a little outwards, or a little inwards at the same time. The backward dislocation most often occurs from a wrench when the foot is flexed. The lateral dislocations when complete are always compound, and nearly always associated with fracture of the malleoli.

FIG. 280.—Dislocation of the foot backwards. (St. Bartholomew's Hospital Museum.)

FIG. 281.—Subastragaloid dislocation. (St. Bartholomew's Hospital Museum.)

Signs.—The astragalus in the *forward* variety can be felt projecting under, and often threatening to protrude through the skin of the instep; whilst in the *backward* form it gives rise to a prominence beneath the tendo Achillis which it causes to bulge backwards, to shortening of the foot, and to a projection of the tibia in front. The *lateral* varieties being compound, the nature of the injury is obvious.

Treatment.—In the simple form attempts should always be made to push back the displaced bone into its socket by making pressure in the proper direction, the calf-muscles being relaxed by position, the foot extended, and the tendo Achillis, or any other tendon or ligament that is felt tense, divided if necessary. An anæsthetic is generally required. If reduction is then found impossible, the rule was to leave the displaced bone alone, and only to excise it if sloughing threatened or had actually occurred. Seeing, however, how successful are the results of excision of the astragalus for intractable cases of club-foot, we should ourselves, if we failed to reduce the bone, remove it at once. In a compound dislocation the bone should, as a rule, be excised.

The subastragaloid dislocation (Fig. 281) is one in which the bones of the foot are displaced from the astragalus, which itself retains its natural connections with the tibia and fibula. The foot is generally displaced either backwards and inwards, or backwards and outwards; more rarely in the opposite directions. In the backward and inward variety (Fig. 281) the foot is inverted, the sole looks inwards, the external malleolus is prominent, the internal malleolus is buried by the projection of the os calcis beyond it, and the head of the astragalus forms a distinct prominence on the outer side of the instep, over which prominence the skin is tightly stretched. In the backward and outward variety the foot is everted instead of inverted, the internal malleolus is prominent, the external buried, and the astragalus projects on the inner side of the instep (Fig. 295 E). The forward varieties are too rare to require description. The normal relations of the head of the astragalus to the malleoli, together with the signs above given, will serve to distinguish it from dislocation of the astragalus alone, the injury with which it is most liable to be confounded. *Treatment.*—In the backward varieties the foot should be drawn forwards, whilst the leg is forced backwards, the tendo Achillis and the tibialis anticus and posticus being divided if necessary after the patient has been put under an anæsthetic. Reduction is sometimes very difficult or even impossible in consequence of the tibial tendons hooking round the head of the astragalus or of the mutual interlocking of the bones. After reduction the foot should be placed on a splint, and an ice-bag applied. If sloughing occurs, *Pirogoff's* or *Syme's amputation* may have to be performed.

Dislocation of the separate bones of the tarsus, of the metatarsal bones, and of the phalanges of the toes are too rare to require special description.

Fractures of the Lower Extremity.

Fractures of the femur may be divided into fractures of—I. *the upper end;* II. *the shaft;* and III. *the lower end.*

I. **Fractures of the upper end of the femur** may be divided into—1, intracapsular fracture of the neck; 2, extracapsular fracture of the neck; 3, fracture of the great trochanter; and 4, separation of the epiphysis of the head.

1. **Intracapsular fracture** occurs most frequently in the old, and more commonly in women than in men. *Cause.*—The atrophy and fatty degeneration of the bone and the diminished obliquity of the neck which is said frequently, though not invariably, to attend old age, are the chief predisposing causes. Prof. Humphry maintained, however, that there is no diminution of obliquity as age advances. Slight indirect violence, such as slipping off the curbstone, catching the toes in the carpet, etc., is the common exciting cause.

State of the parts.—The line of fracture (Plate XVI.) may be situated at any part of the neck within the capsule, and may be transverse or oblique; the usual situation, however, is just external to the head, and the direction transverse. The fragments may be impacted or non-impacted, but impaction is the exception. In the impacted form the lower fragment is nearly always driven into the upper; when, however, the fragments are very jagged, mutual interlocking may occur. The periosteum covering the neck—the cervical reflection as it is sometimes called—may be partially or completely torn, so that all connection between the head and the rest of the bone is severed. Upon the extent of its rupture will in part depend the amount of displacement of the fragments, and the kind of union that will occur. In the non-impacted form the lower fragment with the rest of the femur is drawn slightly upwards by the muscles inserted into the trochanters, and at the same time generally rotated outwards. The outward rotation would appear to depend in part on the direction of the line of fracture, and in part on the weight of the limb, which has a natural tendency to roll outwards. *Method of union.*—In consequence partly of the feeble blood supply of the upper fragment, and partly of the fragments not being in apposition, bony union seldom occurs, the parts becoming bound together by fibrous tissue or remaining ununited. In the latter case the fragments become rounded off and polished, forming a false joint; whilst, owing to the absorption of the lower fragment, great shortening of the neck usually ensues.

Signs.—Slight shortening—about three-quarters of an inch, eversion, inability to raise the limb from the horizontal position, approximation of the great trochanter to the anterior superior spine of the ilium, rotation of the great trochanter through a smaller arc than on the opposite side, and crepitus, are the usual signs. Occasionally there may be no shortening at first, and patients have been known to walk after the injury. In rare instances there has been inversion instead of eversion, a fact not easy of explanation. In the *impacted form* there is no crepitus, the shortening is less, and does not disappear on extension, and the patient may be able to raise the limb from the horizontal position, and perhaps stand or walk on it. *Diagnosis.*—The age of the patient, the very slight shortening, the absence of bruising about the trochanter, the slightness of the violence occasioning it, and the eversion of the limb, are the chief signs which point to intracapsular fracture; but it may have to be diagnosed from the extracapsular form, from dislocation of the hip, from dislocation with fracture of the acetabulum, from chronic osteo-arthritis, and from mere contusion of the hip. In the *extracapsular* form the shortening is greater, the patient usually younger, the occasioning violence direct and more severe, and there is often bruising and ecchymosis of the skin and widening of the trochanter. In *disloca-*

PLATE XVI.

Intra-capsular fracture of the neck of the femur. (From a skiagram taken by Dr Hugh Walsham.)

[*To face p.* 614.

tion there is loss of mobility of the limb, and the head of the bone can be felt in the abnormal position. The only common dislocation with which the ordinary form of fracture could be confounded is the pubic, as in this alone is there any eversion; but here the distinct prominence formed by the head of the bone on the pubes at once serves to distinguish it. In *fracture of the acetabulum with dislocation* there is, in addition to crepitus, the presence of the head of the bone in an abnormal situation, whence it can be drawn on extension of the limb, but returns when the extension is relaxed, crepitus during these movements being felt. *Chronic osteo-arthritis*, in which in consequence of the absorption of the head of the bone there is often shortening and eversion, and in consequence of the movement of the osteophytes upon each other crepitus, may be distinguished from intracapsular fracture, which it may simulate, should a patient suffering from it have a fall, by the history of pain, lameness, and stiffness before the injury. In *contusion* of the hip, though there may be eversion of the limb and loss of power, the trochanter retains its normal relations, and there is no shortening or crepitus. It should be remembered, however, that in old people absorption of the neck of the bone may slowly take place after a contusion, and of this the patient should be warned, as otherwise the surgeon may be accused of overlooking a fracture.

The treatment should vary according to the age and powers of the patient. Thus in the old and feeble in whom bony union can scarcely be expected, and in whom, moreover, long confinement on the back is liable to produce bedsores and even fatal hypostatic congestion of the lungs, the limb should be merely placed at rest between sand-bags, and the patient only confined to bed for a few days. He should then be allowed to get about on crutches with the parts secured in some form of stiff bandage or moulded leather case, or on a Thomas's hip-joint splint. In younger and fairly vigorous patients an attempt may be made to obtain bony union either by means of extension with the weight and pulley or by the long splint, or even by uniting through an open wound. Confinement to bed for six or eight weeks is usually necessary, followed for another two or three months by the use of some form of stiff apparatus.

2. **Extracapsular fractures,** though more frequent in the old than in the young are not, like intracapsular fractures, so essentially an injury of old age. Thus, they are frequently met with between the ages of forty and fifty, whereas intracapsular fractures hardly ever occur in persons under fifty. *Cause.*—Usually direct violence, as a fall or a severe blow on the great trochanter. *State of the parts.*—The fracture commonly extends through the base of the neck just outside the capsule, and is nearly always associated with a fracture of the great trochanter. It may

be impacted or non-impacted, the former condition, however, being by far the most common. Indeed, it is probable that nearly all extracapsular fractures are in the first instance impacted and accompanied by fracture through the great trochanter, and that they only become non-impacted by the splitting asunder of the trochanters, in consequence of the neck being driven in still further wedge-wise between them; and hence that non-impaction only occurs as a result of great violence. The line of fracture through the trochanter commonly extends obliquely downwards and backwards, and terminates by passing through the trochanter minor; but it

Fig. 282.—Extracapsular fracture of the neck of the femur.

Fig. 283.—Fracture of upper third of femur. (After Gray.)

may take various directions, sometimes splitting the trochanter into several pieces. The *method of union* is generally bony, and as the blood supply is very good, there is often an excessive formation of callus. In rare instances no union or fibrous union occurs.

The *signs* are similar to those of the intracapsular variety. Thus (Fig. 282), there is eversion and shortening of the limb, pain on movement, inability as a rule to raise the limb from the ground, and the top of the trochanter is found to be above Nélaton's line (Fig. 271), and the base of Bryant's triangle to be less than on the sound side. But the shortening is greater than in intracapsular fracture; the patient is commonly not so old; the fracture is probably produced by direct violence; the trochanter feels *enlarged* and *broader* than that of the opposite side, from being split by the

neck; there is swelling and bruising about the hip; and often much subsequent ecchymosis, since the blood being outside the capsule readily makes its way to the surface. In the *non-impacted* variety where there is much comminution of the trochanter, the shortening may be as much as two or three inches, and crepitus will be well marked. In the *impacted*, the shortening is much less, seldom exceeding an inch, and crepitus cannot be elicited, unless the fragments are loosely wedged. In firm impaction, indeed, the patient can often raise the leg, or even walk.

Treatment.—In the non-impacted variety, extension should be applied by means of some variety of Liston's long splint, a stirrup, weight and pulley being substituted for the perineal band. Firm osseous union will generally be obtained in a month to six weeks. If impacted with deformity it should be forcibly broken down under an anæsthetic, and extension applied. Union will then occur with less than an inch of shortening. If the impaction is allowed to remain there will be an inch or more of shortening, and probably some eversion and stiffness of the joint with permanent lameness.

3. **Fracture of the great trochanter**; and 4, **separation of the epiphysis of the head,** are too rare to call for description here. One of us (Walsham), however, has recently had two cases of separation of the epiphysis under his care. The signs were those of the intra-capsular fracture, and the diagnosis was verified by the *x* rays. They were treated by extension with long splint, weight and pulley, and did well.

II. **Fractures of the shaft of the femur** are very common in children, less common in adults, and rare in old people, in whom intra- and extra-capsular fractures more readily occur. *Cause.*—Generally the result of indirect violence, occasionally of direct, and rarely of muscular action. *State of the parts.*—The line of fracture is usually transverse or oblique; but in rare instances, almost longitudinal or spiral. The oblique is more common in adults; the transverse in children. The fragments for the most part considerably overlap, producing much shortening. The usual situation of the fracture is about the middle of the bone, though it may occur through the upper or middle or lower third. In the *upper third* (Fig. 283), the lower end of the upper fragment is drawn forwards by the psoas and iliacus, and at the same time, generally abducted and rotated outwards by the glutei and external rotator muscles. The upper end of the lower fragment is drawn inwards by the adductors, and upwards by the quadriceps and hamstrings, whilst it is also rotated outwards in part by the adductors, and in part by the weight of the limb. Occasionally, the upper fragment is drawn inwards instead of outwards. Union is apt to occur with some overlapping of the fragments and angular deformity. In the *middle third* the displacement is similar, the upper fragment usually projecting in front and to the outer side of the lower. In

the *lower third* the upper fragment, in addition to being displaced forwards, is generally drawn towards the middle line by the adductors; whilst the lower fragment, especially when the fracture is just above the condyles, is tilted backwards into the popliteal space by the gastrocnemius, where it can be felt as a distinct prominence, and at the same time is drawn upwards with the rest of the limb by the hamstrings and quadriceps (Fig. 286).

Signs.—In the adult the signs are usually very obvious. They consist in shortening, crepitus, eversion of the foot, swelling from the approximation of the attachments of the muscles, and in preternatural mobility and loss of power in the limb. The ends of the fragments, moreover, can often be felt on manipulation. In young children the diagnosis is not always so easy, especially when the fracture is incomplete; the bowing of the limb, shortening, sensation of yielding or creaking, and the history of the accident, however, will usually prevent a mistake.

Treatment.—The methods of treating fractures of the shaft of

Fig. 284.—Liston's long splint. (Heath's Minor Surgery.)

the femur are very numerous; they have all for their object the extension of the limb. Extension overcomes the spasmodic contraction of the hamstrings and adductors, and through the insertion of the quadriceps into the anterior surface of the upper fragment draws the lower end of the latter backwards, thus counteracting the psoas and iliacus. The various methods may be briefly considered under the following heads:—1, the long splint; 2, the weight and pulley; 3, the double-inclined plane; 4, the plaster-of-Paris or starch bandage.

1. *The long splint* (Fig. 284) in its simplest form consists of a straight lath with two notches at its lower, and two holes in its upper end, and is known as Liston's. It should reach from the axilla to six inches below the foot. The splint, well padded, is first bound to the foot and leg by a bandage carried through the notches in the splint, and over the ankle in the form of a figure of **8**, and then up the leg, and beyond the knee to prevent relaxation of the ligaments of the joint (Fig. 284). A perineal band having been previously adjusted, and its ends brought out through the holes in the top of the splint, is now tightened, whilst extension is made upon the foot. The ends of the perineal band, as soon as

the fracture is reduced, are securely tied. The band thus acts as a counter-extending force, and the displacement is prevented from returning. A broad bandage is finally passed round the thorax to confine the splint to the side. The perineal band may consist of any soft material, as a folded silk handkerchief, or "piece of bandage sewn in the form of a long bag and stuffed with cotton-wool," with tapes attached at each end. It should take its bearings from the tuber ischii, and not rest between the tuber ischii and great trochanter, as here it would press on the great sciatic nerve. The splint is improved by a cross-bar at its lower end, to prevent the limb rolling outwards, and by an oval aperture opposite the external malleolus, to prevent pressure on that bone. As the perineal band is apt to chafe, most surgeons, in its place, employ, in combination with the long splint, the stirrup, weight and pulley for the purpose of extension, raising the bed at the foot so that the weight of the body may act as the counter-extending force. Many modifications of the long splint are in use; amongst these may be mentioned Boyer's, Desault's, Bryant's, and De Morgan's splints. Bryant's (see *Diseases of Hip*) consists of two long splints united above and below by iron cross-bars in the way shown in the drawing, and interrupted opposite the trochanters to avoid pressure on these parts. By its use both limbs are kept parallel, and abduction or adduction of the fractured limb is prevented, whilst extension is kept up by means of the elastic apparatus attached to the side of the splint, and connected by cords and pulleys to the foot-piece, which moves up and down in a slot. If the foot of the bed is raised no perineal band is required.

Fig. 285.—Fracture of the femur treated by vertical extension. (Bryant's Surgery.)

2. *The weight and pulley* is frequently used, either alone, or as an addition to the long splint. A long piece of strapping is secured on each side of the leg and lower third of the thigh by strapping and a bandage, leaving a loop about eight inches long under the sole. In the loop thus left a flat piece of wood, about two inches square, is placed, and through a hole in the centre of this a cord is passed and secured by a knot at its end. The cord is then carried over a pulley at the foot of the bed, and a weight of several pounds suspended on it. The weight should be gradually increased till the fractured limb is found on measurement to be the same length as the sound limb. Ten to twenty pounds or even more may be required. Counter-extension is made by the weight of the body, the foot of the bed being raised six inches or so on blocks.

But the many details involved in its application will be better learnt by three months' dressing in the wards than by any verbal description. In children, the limb, or better both limbs, may be suspended by means of this stirrup in a vertical position to the ceiling (Fig. 285), the weight of the body being the counter-extending force.

3. *The double-inclined plane* is very useful in the treatment of fractures of the upper third of the femur, in which the upper fragment is tilted upwards by the psoas and iliacus, and cannot be kept in apposition with the lower. By means of the double-inclined plane the lower fragment is raised and brought into line with the upper, extension being secured by the leg and foot hanging unsupported down the further side of the plane, and counter-extension by the weight of the body. The plane may consist of an ordinary MacIntyre's splint bent to the proper angle, or of a wooden frame that can be adjusted to the proper height at the apex where the planes meet. Dr. Hodgen's and Dr. Nathan Smith's splints are double-inclined planes slung on pulleys. The method of applying Hodgen's splint is shown in Fig. 287.

Fig. 286. — Fracture of lower third of femur. (After Gray.)

4. *Plaster-of-Paris and starch bandages* are employed at some hospitals from the first, and the patient allowed to get about on crutches.

III. **Fractures of the lower end of the femur. A. Separation of the lower epiphysis of the femur.**—This is the most important of epiphysial separations, and the gravity of the accident is such that in some half of the recorded cases amputation has had to be resorted to. It takes place at ages between eleven and twenty, especially after fourteen years and in boys, rarely below that age or in girls. It is especially caused by indirect violence consequent upon entanglement of the leg in a revolving carriage wheel or in a running rope, or from falling between joists. Less often it has happened from falls on the knee, also from alighting with the knees wide apart as in playing leap-frog, *i.e.*, by over-extension and violent twisting. It may also be occasioned by direct violence. Separation may occur without displacement when soft crepitus is obtained; with incomplete or complete displacement it is likely to be accompanied by fracture of the diaphysis, but not by intercondylar fracture into the knee-joint. The displacement is generally of the epiphysis with the limb below, forwards in front of the diaphysis, the attachment of the gastrocnemius serving to tip the separated surface of the epiphysis more and more backwards. At the same time the lower end of the diaphysis is pushed backwards into the popliteal space,

where the popliteal vessels and nerves are stretched over it. Extensive stripping up of periosteum from the diaphysis may occasion much hæmorrhage, which collects about the fragments or flows from the wound if compound. Traumatic aneurysm and hæmorrhage may likewise occur from rupture of the popliteal vessels, and gangrene has followed obstruction to the popliteal vein stretched over the end of the upper fragment. The popliteal nerves may be ruptured. Acute suppuration and necrosis may ensue even although the injury be not compound.

Treatment.—Immediate reduction is necessary. This is generally accomplished by strong flexion, even until the heel touches the buttock, combined with traction on the tibia and manipulation, and,

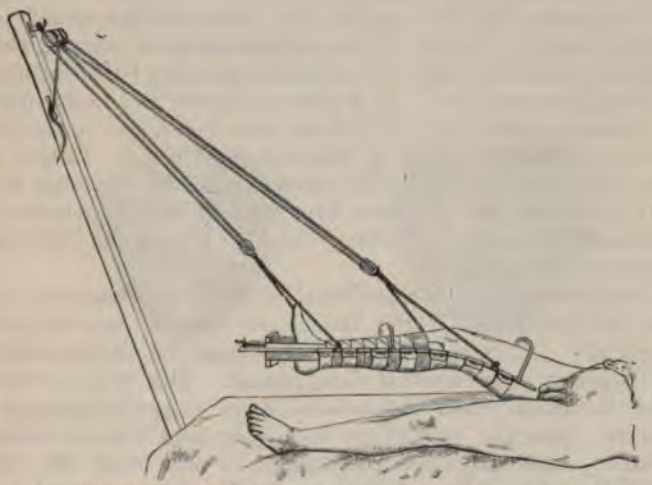


Fig. 287.—Hodgen's splint for fracture of the femur. (Heath's Minor Surgery.)

if need be, with division of the tendo Achillis, to relax the gastrocnemius. Failing this, reduction and fixation by the open method, with removal of clot and arrest of hæmorrhage, is essential to avoid amputation.

B. **Fractures through the lower end of the femur** occur in adults, especially from falls on the knee. The fracture is often oblique running (see Fig. 286) from above downwards and forwards. The upper fragment is displaced forwards, being felt beneath the vastus internus, or it may lacerate the knee-joint into which blood is extravasated; or by further violence, the sharp end is driven through the skin to the inner side of the patella, the wound in the skin thus communicating not only with the fracture but also with the knee-joint. The lower fragment is at the same time pushed backwards by the displacement of the upper fragment in front of it, and is also drawn backwards by the gastrocnemius.

Thus the upper end of the lower fragment protrudes into the popliteal space, where it may stretch or lacerate the popliteal vessels and nerves.

The fracture may also run obliquely or vertically through the condyles separating one or both from the shaft, and thus producing a T-shaped fracture into the joint.

The *diagnosis* is made by the condyles being found to move on the shaft with sharp crepitus, or to move on one another. Separation of the epiphysis will be distinguished, as above described, by the age of the patient, the soft crepitus, and the displacement of the lower fragment forwards, whilst the knee-joint generally escapes. When there is already much swelling, examination by the *x* rays and under an anæsthetic is necessary.

Treatment.—The limb may be fixed with the knee semi-flexed or fully extended. The former has the advantage of relaxing the calf muscles so that the fragments come into position, but if maintained too long, the knee-joint may become ankylosed in a faulty position. A Hodgen's splint (Fig. 287) allows more movement to the patient than a MacIntyre's splint, or double-inclined plane. Passive movement and massage are required as soon as possible. The tendo Achillis may be divided and the knee kept straight with an outside splint and weight extension. The knee, should it become ankylosed, is in a relatively good position.

Complications.—1. Simple fracture, with extravasation of blood into the knee-joint. If the knee is very tense it may be aspirated aseptically. 2. Simple fracture, with separation of the semilunar cartilages or other internal derangement. This will be found to limit movement when the patient begins to get about, and may require operation (p. 610). 3. A compound fracture must be treated immediately and thoroughly, or the blood-clot will be infected, suppuration follow, and then amputation. After thoroughly cleansing the skin and the protruding fragment, the wound is freely enlarged upwards and downwards, all blood-clot washed out of the joint and from around the ends of the bone, whilst tying bleeding vessels like the anastomica. Then the wound may be sewn up with a drain-tube inserted or the knee packed with gauze, the fragment having been fixed by pegging or wiring. 4. Fracture, simple or compound, with injury to the popliteal vessels. The treatment in such an accident is amputation for the worst cases, but this should be avoided if possible by cutting down upon the ruptured vessels in the popliteal space and ligaturing both ends whilst turning out all clot which otherwise would obstruct the anastomotic circulation. When the wound is fairly aseptic, even if gangrene ensues it will be dry and at first limited to the foot, affording an opportunity for a secondary amputation. When, however, there has been much loss of blood, the anastomosis is likely to be insufficient, and a septic condition of the wound would surely be

followed by moist gangrene, which it is better therefore to anticipate by amputating at once. If there remains excessive mobility, the fracture should be subsequently pegged or wired.

The patella.—Fractures of the patella are most common in middle life, of more frequent occurrence in men than in women, and very rare in childhood. *Cause.*—They are generally due to a sudden and violent action of the quadriceps extensor muscle, such as is exerted by a person to regain the upright position when he feels himself slipping backwards, the knee being then semi-flexed, and the patella unsupported. They are sometimes caused by direct violence, as a blow or fall upon the knee. *State of the parts.*—When due to muscular action the line of the fracture is transverse (Fig. 288), the aponeurotic covering is usually torn, and the upper fragment generally drawn some distance from the lower by the action of the quadriceps extensor. When due to direct violence it is more often starred or vertical (Fig. 289), and the aponeurosis

Figs. 288 and 289.—Transverse and vertical fracture of the patella.

being intact there is little or no separation. In any case the fracture, of course, extends into the joint. *Method of union.*—When the fracture is transverse and the aponeurosis torn, unless the fragments are wired, union is generally fibrous or membraneous, rarely osseous, in consequence of the fragments being separated, in part by muscular contraction, in part by the effusion of blood and later of serous fluid into the joint, but chiefly by flaps of the torn aponeurosis falling between the fragments. In the vertical and starred fractures, where the parts are held together by the untorn aponeurosis, union is usually osseous. *Signs.*—At first a gap between the fragments can be seen and felt, but it is subsequently obscured by swelling of the joint. The patient cannot stand, or extend the knee. In a vertical fracture crepitus can usually be detected, and the fragments are not separated.

Treatment.—Antiseptic surgery has completely revolutionised the treatment of fracture of the patella, and there can be no doubt that for all suitable cases with marked separation wiring of the fragments is the best treatment. It should not be lost sight of, however, that wiring has been followed by suppuration, stiff joint, amputation, and even loss of life. In face of these facts, therefore, no surgeon should

attempt wiring unless he is thoroughly familiar with the antiseptic treatment of wounds and is sure that this treatment can be rigorously carried out. Nor should wiring be undertaken where the patient's constitution is broken down from abuse of alcohol, or from Bright's disease or diabetes.

Wiring the patella may be done by the open or by the so-called subcutaneous method.

(*a*) *The open method* has the advantage that the joint can be thoroughly cleansed of all blood-clot and the flaps of aponeurosis removed from between the fragments. The operation is perhaps best done three or four days after the accident, the patient in the meantime being confined to bed with his knee on a splint. The skin having been rendered thoroughly aseptic, the fracture is exposed by a vertical or curved incision a little to one or other side of the middle line of the patella, down to the bone. The flaps of aponeurosis are next peeled off the fractured surfaces, and all blood-clot washed out of the joint. Each fragment is next drilled obliquely from the anterior surface to the lower part of the fractured surface just above the cartilage, so that the wire when passed and tied is not in the interior of the joint (see Plate XVII.). The flaps of aponeurosis between the fragments should be held up with forceps so that the bony surfaces are brought accurately into contact. The wire is now twisted tight, cut off, and the ends battered down level with the bone with an aseptic mallet, the aponeurosis over the patella and at its sides brought together by kangaroo-tail tendon sutures, the wound closed and dressed antiseptically, and the limb placed on a splint.

Fig. 290. — A patella divided vertically to show the method of wiring. (St. Bartholomew's Hospital Museum, No. 988 *b*.)

If the skin incision is made to one side of the middle line and the wire is inserted through the middle of the patella, the cicatrix in the skin will be half an inch or so to one or other side of the wire. The limb should be kept on the splint for ten to fourteen days and passive movements of the joint then begun. The patient should be able to walk with a freely moveable joint at the end of three weeks. Fig. 290 and the skiagram (Plate XVII.) show the accurate apposition and bony union so obtained.

(*b*) *The subcutaneous method* as employed by Mr. Barker is most suitable immediately after the accident, before much blood has escaped into the joint and the tissues around are not swollen. It may also be safely done in older patients than the open method,

PLATE XVII.

Skiagram of a fractured patella in which the fragments have been wired. (Taken by Dr. Hugh Walsham at St. Bartholomew's Hospital.)

[*To face p.* 624.

e.g., in patients over sixty years of age. The greatest care must be taken to prevent the entry of any organisms. Mr. Barker ties the fragments together subcutaneously by thick, soft silver wire (Fig. 291). A small incision is first made into the joint through the ligamentum patellæ immediately below the lower fragment and the blood squeezed out. A curved needle on a handle is carried through this incision, then up behind the patella, and brought out through the skin immediately above the upper fragment. It is next threaded and withdrawn. After being unthreaded it is repassed through the same incisions, but now up between the patella and the skin, threaded

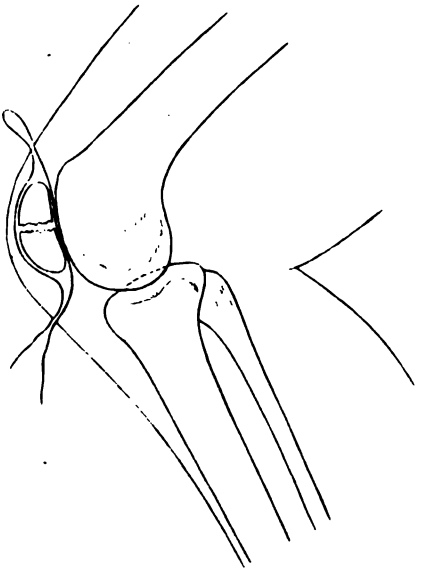


Fig. 291.—Wiring a fractured patella by Barker's subcutaneous method. The wire inserted ready for tightening.

with the other end of wire projecting from the puncture above the patella and again withdrawn. The ends of the wire (Fig. 291) are now twisted, after strongly drawing the fragments together, then cut off short. The wire must lie exactly in the middle line so that the fragments shall not tip aside, and an assistant must, with the thumb and finger, take hold of each fragment, and by moving them on one another get rid of any intervening aponeurosis and then hold them in apposition whilst the wire is being tightened. The cut end of the twisted wire must be turned backwards into the ligament.

The operation is readily carried out when swelling has not yet started, also the aponeurosis can then be got away from between the fragment, whereas after a few hours it gets glued to the fractured

surface, so as to prevent a strong union. The wire must not be twisted too much or it will give way at the first twist, and it should be thick, soft silver wire. Its ends must not be allowed to protrude forwards through the puncture or under the skin. By these measures some of the objections to the method, viz., failure to obtain strong union owing to the intervention of aponeurosis, breaking of the wire, or its ulceration through the skin, may be avoided. The punctures are covered with collodion dressing, and the patient encouraged to move his knee; after a week the patient in some cases has been able to swing his knee or walk about, but in other cases much stiffness has ensued and a perfect range of movement has not been gained.

Non-operative treatment.—When it is not thought advisable to wire the patella, or when there appears to be practically no separation, the best treatment is free movement and use from the first, by which are avoided adhesions in the joint and the weakening of the

FIG. 292.—Manning's patella splint. The leg is drawn in outline, so as to show beneath it the webbing band passing through the slit in the splint. The strips of strapping should reach up the thigh to the gluteal fold.

thigh muscles. The joint is treated with cold lotions until the swelling subsides a little, then passive movement with massage is performed daily, and the patient is encouraged to use the limb as much as possible. A strong fibrous band unites the fragment, so strong that a patient has often refractured the patella through the bone and not through the fibrous union.

All measures involving fixation of the knee are unsatisfactory. The fragments are not kept permanently in apposition and bony union does not take place, only fibrous; meanwhile adhesion sticks the patella to the condyles, and the muscles, especially the quadriceps extensor, waste from disuse. Either an ankylosed knee or a weak knee results, the patient never regains a useful limb, is hindered in his occupation, and is liable to fracture the opposite patella, from the sudden yielding of his weak leg. The knee has been kept in plaster of Paris for ten weeks or so and then a leather knee-cap applied, or the knee has been fixed on a back splint and the upper fragment drawn down by strapping, webbing, or elastic bands. Fig. 292 shows Manning's splint, which was formerly much employed for this purpose.

Short of wiring, perhaps Mr. Mayo Robson's method of holding the fragments together by hare-lip pins and figure-of-eight ligatures is the best (see Fig. 293). The pins are inserted through the quadriceps extensor and the ligamentum patellæ, neither penetrating the joint, and they remain *in situ* for a month. Its disadvantages are, as compared with the subcutaneous method, that blood extravasated cannot be squeezed out; with the open method, that the aponeurosis is left between the fragments; and with both, that movements cannot be begun early. Less satisfactory still are "tyring methods," *i.e.*, attempts to run a silk ligature round the circumference of the patella, or fixing it with Malgaigne's hooks.

The tibia and fibula.—Both bones, or the tibia or fibula alone, may be fractured.

Fracture of both bones, which is by far the most common variety, may be due to either direct or indirect violence. When the result of direct violence, the fracture occurs at the spot where the force is applied, and both bones are usually fractured more or less transversely, and in the same line (Fig. 103, p. 252); but when the result of indirect violence, the tibia generally first gives way at its weakest spot, *i.e.*, about the junction of the middle with the lower third, and then the fibula also at its weakest spot, *i.e.*, in its upper third, and the fractures are usually oblique (Fig. 294). In the transverse fracture but little displacement occurs; in the oblique, in which the line of fracture usually runs downwards, forwards, and a little inwards, the lower fragments are drawn upwards, backwards and outwards, behind the upper, by the muscles of the calf, while the sharp end of the upper fragment of the tibia projects forward threatening and indeed often causing perforation of the skin (Fig. 296).

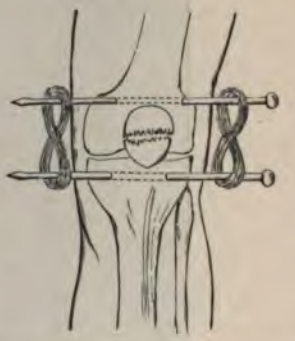


FIG. 293.—Mayo Robson's method of holding fragments of patella in contact.

Fracture of the tibia alone is generally *caused* by direct violence, as a kick or blow on the shin, occasionally by indirect violence, as a fall on the foot. *Nature of the displacement.*—The fracture is usually situated in the lower third of the bone, and is generally transverse, and attended by little displacement, the fragments being held in position by the fibula, which plays the part of a splint; but it may be oblique as in Fig. 297. Fractures of the upper and lower ends, involving the knee- and ankle-joints respectively, and separation of the upper and lower epiphysis, may also occur, but are rare.

Fracture of the fibula alone is more common than fracture of the tibia alone. *Cause.*—Though sometimes caused by direct it is more

often the result of indirect violence, such as a severe wrench or twist of the foot. The fracture is then generally situated from two to three inches from the external malleolus, and the foot is at the same time very commonly dislocated either outwards or inwards (Fig. 295), according to the direction of the force. *Nature of the displacement.*

Fig. 294.—Oblique fracture of the tibia and fibula with displacement of the fragments. (From a skiagram taken by Dr. Hugh Walsham.)

—In the fracture with outward dislocation of the foot (*Pott's fracture*, as it is generally called), the upper end of the lower fragment is driven inwards towards the tibia, the internal lateral ligament is ruptured, or the end of the internal malleolus is torn off (Fig. 298). The foot, at the same time that it is displaced outwards, is also drawn *backwards* by the tendo Achillis. In the fracture with inward dislocation (which is rare), the articular surface of the external

malleolus usually follows the astragalus, and the upper end of the lower fragment of the fibula in consequence projects outwards.

Signs.—In fracture of both bones the signs are usually unmistakable, especially when the fracture is oblique and in the lower third of the leg. When the tibia or fibula alone is fractured the diagnosis is often very difficult. In the tibia some irregularity may be felt on running the finger along the shin, and crepitus may

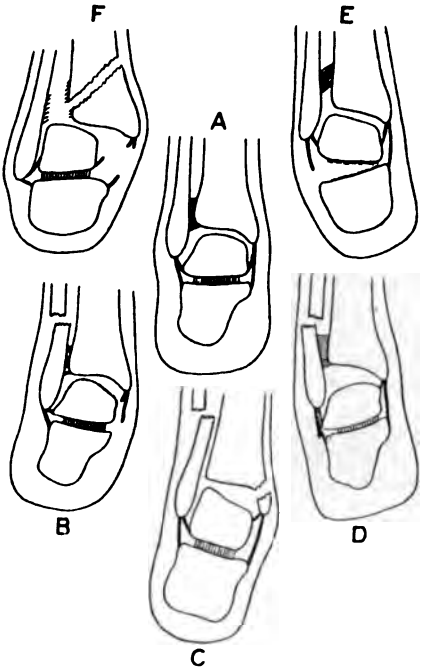


FIG. 295.—Diagrams illustrating injuries about the ankle-joint. (After Treves.) A. Normal. B. Pott's fracture, with rupture of the internal lateral ligament. C. Pott's fracture, with fracture of the internal malleolus. D. Fracture of the fibula and displacement of the foot inwards. E. Subastragaloid dislocation. F. Dupuytren's fracture, *i.e.*, rupture of the interosseous membrane, oblique fracture of the tibia, rupture of the internal lateral ligament.

perhaps be elicited. In the fibula, fracture of the lower third may be detected by running the finger along the subcutaneous surface of the bone just above the external malleolus; but if the case is not seen till swelling from effusion has set in, it may be quite impossible to say whether we are dealing with a fracture or a sprain. If in doubt the case should be treated as a fracture. In the upper two-thirds, where the bone is covered with muscles, and cannot be felt, the following tests for fracture may be applied. 1. Move the foot laterally, and crepitus will probably be elicited if there is a fracture.

2. Press the tibia and fibula together just above the ankle by grasping them with the hand. In fracture, pain will be felt at the fractured spot, not at the situation where grasped. 3. Grasp the tibia and fibula with the hands just below the knee and above the ankle. If there is a fracture the natural springiness of the fibula will be lost, and crepitus may perhaps be detected. In *Pott's fracture* (Fig. 299), the foot is twisted outwards, so that whilst the inner edge is towards the ground the sole is directed outwards. There is a well-marked depression over the seat of fracture, the internal malleolus projects prominently under the skin, and crepitus can be easily obtained. There is also marked *backward* displacement of the foot.

Fig. 296.—Fracture of the lower third of the tibia. (After Gray.)

Treatment. — In uncomplicated fractures of the tibia or fibula alone, the leg may be placed at once in plaster-of-Paris splints, and the patient, after a few days' rest in bed, allowed to get about on crutches. Where there is much swelling, the leg had better be placed for a few days on a back splint to allow the swelling to subside before the plaster of Paris is applied. In simple fracture of both bones, where the line of fracture is transverse and there is but little swelling or displacement, the same treatment may often be adopted with advantage. But greater care and watchfulness will be necessary to prevent any untoward accident. Indeed, whenever this method of treating fractures is used, the precautions mentioned at pp. 244 *et seq.* should be taken. When there is any displacement, however, the fracture must be reduced by making traction upon the foot whilst the thigh is steadied by an assistant, special care being taken to correct the eversion, so frequently present, of the lower fragment. The surgeon will know when this has been done by the inner side of the patella, the internal malleolus, and the inner side of the great toe being in the same line. Further, he should not, as a rule, rest satisfied as long as any irregularity can be felt on drawing the finger down the crest of the tibia, or as long as any marked difference is apparent on comparing the fractured with the sound leg. If any difficulty is experienced, give an anæsthetic, and, if necessary, cut the tendo Achillis. Having reduced the fracture, secure the foot and leg on a splint. Whatever form of the various splints for the purpose is adopted, take care :—1, that the foot is at a right angle to the leg; 2, that the ball of the toes and the heel

piece of the splint; 3, that the foot is square with the
4, that the back of the heel is kept from contact with
small pad placed under the tendo Achillis just above
iron splint and cradle, shown in Fig. 300, is almost
loyed by the whole of the surgical staff at St.

7.—Skiagram of an oblique fracture of the tibia. (Taken by Dr. Hugh Walsham at St. Bartholomew's Hospital.)

w's Hospital for ordinary fractures of the tibia and fibula
he most satisfactory results. In applying the splint,
ld reach as high as the junction of the middle with the
of the thigh and should be well padded and shaped to
he foot is first secured to the foot-piece by strapping and
. The surgeon having then assured himself that the

fracture is in good position, secures the splint by a broad strip of strapping, and a figure-of-eight bandage over the knee. The splint is next swung in the cradle, as shown in the figure, and side splints are then applied and fixed by webbing straps. In the case of fracture of both bones, the apparatus is generally kept on for a month ; in the case of the fibula or tibia alone, for two or three weeks. The

Fig. 298.—Skiagram of a Pott's fracture. The internal malleolus is fractured. (Taken by Dr. Hugh Walsham at St. Bartholomew's Hospital.)

leg is then placed in a plaster-of-Paris, a gum and chalk, or a silicate of soda bandage. In *Pott's fracture*, the above apparatus is also generally used, and here again we speak of it in the highest praise. Where, however, there is much difficulty in keeping the bones in good position, the leg is sometimes laid on its outer side, with the knee semi-flexed to relax the gastrocnemius, and secured in Cline's splints (Fig. 301), the tendo Achillis being divided, if found necessary. The backward displacement of the heel, however, is best corrected

by using Roughton's modification of this splint (Fig. 302). It consists of an outside splint with a foot-piece. The heel is drawn forward and secured in position by a "heel bandage," the limb being fixed to the

FIG. 299.—Pott's fracture. (St. Bartholomew's Hospital Museum.)

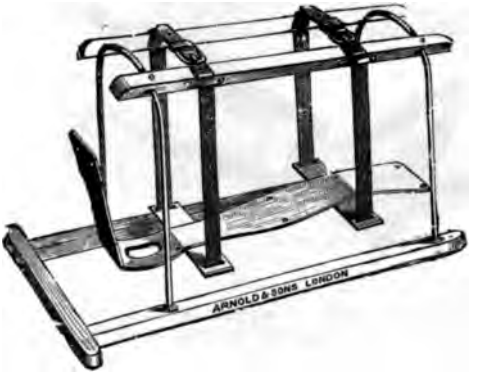


FIG. 300.—Fracture apparatus or cradle for the bones of leg.

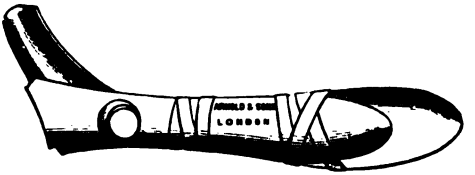


FIG. 301.—Cline's splints for Pott's fracture. The outside splint is known by the foot-piece.

splint by two other bandages, one placed just above the ankle and the other just below the knee (Fig. 303). At times Dupuytren's splint (Fig. 304) may be better adapted to a particular case. The splint con-

sists of a straight lath notched at its lower end. It is placed on the inner side of the limb, and should reach from the tuberosity of the tibia to three or four inches below the foot. A wedge-shaped pad, with its base below, and not extending beyond the internal malleolus, should

Fig. 302.—Modified Cline's splint for Pott's fracture.

line the splint. The splint is bandaged on from above downwards, and the leg having been thus secured, the foot is brought over to the splint by making figure-of-eight turns over the ankle and foot and through the notches at the lower end of the splint. The bandage should not

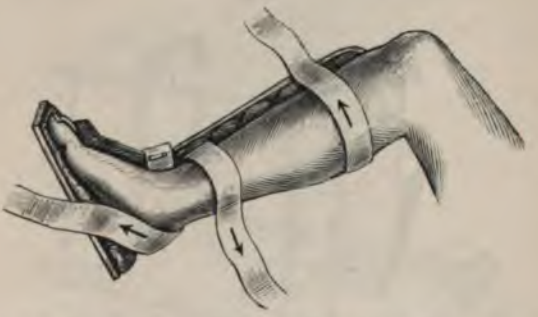


Fig. 303.—Roughton's method of applying the modified Cline's splint in Pott's fracture. The arrows show the direction in which the bandages pull.

pass over the external malleolus or the seat of fracture. The great objection to the use of this splint is, that having no foot-piece, the foot is not kept at a right angle to the leg. When no special apparatus is at hand, the fracture, whether of both bones of the leg

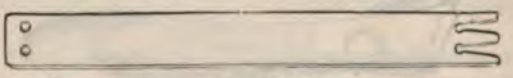


Fig. 304.—Dupuytren's splint for Pott's fracture.

or of one bone only, may be put up in what is known in Edinburgh as the box-splint (Figs. 305, 306). All that is required is two ordinary side splints and some towels, cotton-wool, and a few bandages. The splints should be rolled in the two ends of a long towel (Fig. 305) so as to form a trough for the fracture, the width of the trough

being determined by first placing the sound leg in it. The fracture having been set, the leg is placed on the towel and the splints forming the sides of the trough or box are raised and secured in position by slip-knot bandages (Fig. 306). Pads formed of folded towels should be placed over the tibia or where required, and the foot fixed at a right angle to the leg by a figure-of-eight bandage (Fig. 306). Backward displacement of the heel may be controlled by a ring pad. Massage should be applied early in all fractures about the ankle.

Cases of *badly-set Pott's fractures* frequently come under notice. In such the foot which has been allowed to remain everted becomes flat, and there is usually much thickening about the internal

FIGS. 305, 306.—The box-splint for fracture of the bones of the leg. In the upper figure the position of a towel used as a pad is shown. In the lower figure the apparatus is shown completed. (After Caud and Cathcart.)

malleolus, limitation of movement at the ankle, and pain on attempting to walk. In recent cases the tendo Achillis should be divided and the foot wrenched until it is fully inverted, and at a right angle with the leg. Massage should be then sedulously applied. In old-standing cases we have succeeded in replacing the foot after osteotomy of the fibula and excision of a wedge of bone from the internal malleolus. The results obtained were excellent; the deformity was overcome and the patient enabled to walk without pain or discomfort.

Fixation of the fragments through an open wound.—Much attention has lately been drawn to the frequency of deformity after fracture of the leg and Pott's fracture. If the directions above given are followed, if especially the patient is anæsthetised, and the fragments freed from muscle by manipulation, and if, when the reduction cannot be easily accomplished, the tendo Achillis is divided,

Wounds of the spinal membranes and cord may be inflicted by stabs in the back, falls on sharp bodies, etc. When the membranes alone are wounded, there may at first be no signs except perhaps an escape of cerebro-spinal fluid; but later, should inflammation be set up, there will be the usual signs of spinal meningitis. A wound of the spinal nerves may be known by paralysis of the parts which they supply; a wound of the cord, by paralysis of the parts below the seat of injury. When division is complete the knee-jerk is quite lost, when incomplete the knee-jerk may be exaggerated. Rapid death follows a punctured wound by a knife or even a needle in the cervical region. The *treatment* consists in placing the patient at absolute rest, and in keeping the wound perfectly aseptic to prevent inflammation; but if the cord has been divided, permanent paralysis will necessarily ensue. Should inflammation occur, the appropriate remedies for meningitis must be administered. (See work on Medicine.) Should suppuration occur the wound must be explored.

Fig. 308.—Fracture-dislocation of the spine. (St. Bartholomew's Hospital Museum.)

Dislocation and fracture.—Dislocation of the spine without fracture is exceedingly rare; indeed, except in the cervical region, it is said never to occur. Fracture unaccompanied by dislocation is also uncommon; but uncomplicated cases of fracture of the spinous processes and laminæ, and more rarely of the transverse and articular processes, are sometimes met with. In the majority of cases fracture and dislocation are combined. Thus, usually there is fracture of the body and articular processes of one or more of the vertebræ, with dislocation of the whole of the spine below the seat of injury from the spine above. This common form of injury is in the context spoken of as *fracture-dislocation*.

Fracture-dislocation.—*Causes.*—It is either the result of *direct violence* applied to the spine, or of *indirect violence*, as a fall upon the head. 1. When the result of *direct* violence, which can only be applied to the posterior part of the spine, one or more of the spinous processes may be detached without implicating the vertebral canal. When the violence is very great, as in a fall from a height on the back across a beam or rail, or a severe blow from a crane, the spine is bent violently backwards, tearing asunder the structures forming the anterior segment of the column, and crushing those forming the posterior. Hence the vertebral bodies are generally uninjured, but wrenched apart, the intervertebral cartilages are ruptured, the anterior common ligament is torn, and the arches of the vertebræ and the articular and spinous processes are crushed.

The vertebræ above the injury are dislocated forwards, as the articular processes being fractured and the intervertebral cartilages torn, nothing remains to keep them in position. 2. In fracture from *indirect* violence (Fig. 308), such as may be received in a fall from a height upon the head, or catching the head whilst passing under an arch, or from a weight falling upon the head or shoulders, the spine is bent violently forwards, crushing the anterior part of the column and tearing the posterior asunder. Here one or more of the bodies and intervertebral cartilages are crushed between the vertebræ above and the vertebræ below, one of the fragments of the fractured body being frequently driven backwards into the vertebral canal, whilst the arches and the spinous and articular processes are wrenched asunder. Fracture of the sternum is occasionally combined with this injury, in consequence, it is said, of the chin coming into violent contact with the sternum as the spine is doubled forwards.

Condition of the spinal cord.—The importance of fracture-dislocation of the spine lies not so much in the fact that the vertebræ are fractured, as that the cord is generally injured. When the vertebræ are not displaced, the cord may at times altogether escape. More commonly, however, it is compressed, or, perhaps, completely divided, or again so bruised that it rapidly undergoes inflammatory softening. When the injury is situated below the second lumbar vertebræ, the cord necessarily escapes, as it terminates at that spot, but the nerves of the cauda equina may then be injured.

Signs and symptoms.—The local signs are often but little marked. There may be pain at the seat of injury, or some inequality in the spinous processes; but as often as not these are absent. The general signs depend upon the condition of the cord, and none will be present when it has escaped injury. But when it is compressed or crushed there will be paralysis of the parts below, more or less complete according to the extent of the lesion. Taking as an example a case of fracture in the lower cervical or upper dorsal region—the most common situation—with severe compression or crushing of the cord, there will be paralysis of both motion and sensation of the whole of the parts below the seat of injury (*paraplegia*), and perhaps a zone of hyperæsthesia immediately above the injured part due to irritation of the nerve-roots that issue just above the damaged part of the cord. The intercostal muscles being paralysed, respiration can only be carried on by the diaphragm, this muscle receiving its nerve-supply through the phrenics which are given off above the seat of injury. Hence, while the chest is motionless, the abdomen rises and falls during respiration. The bladder and rectum and their respective sphincters share in the paralysis, so that there is at first retention of urine and fæces, followed by passive overflow

of urine as the bladder becomes distended and will hold no more, and by involuntary passage of fæces. Priapism, or involuntary erection of the penis, is frequently present, or is induced by the use of the catheter. The temperature varies; sometimes it may be lower than normal, but often it is considerably raised, even reaching as high as 107° shortly before death. Consciousness, unless any head-injury has been received at the same time, is not affected. The reflexes in the lower limbs are usually at first in abeyance, but may return if the patient does not succumb to the shock of the injury. If the deep reflexes remain quite lost the probabilities are that the conducting power of the cord has been completely destroyed. If they return it is a sign that some power of conductivity is left in certain portions of the cord at the seat of injury. Death occurs, as a rule, from twenty-four hours to a few days from bronchial trouble; but the patient, if the fracture is in the upper dorsal region, may linger from two to three weeks. The secondary troubles which are then generally met with are *bedsores* and *chronic cystitis*. 1. The bedsores occur in situations subjected to pressure, and depend in great part on the congestion and lowered vitality of the tissues induced by the impairment of the nerve-influence; but they may also to some extent be due to the soddening of the part with the urine and fæces from which it is very difficult to keep the patient free. 2. The chronic cystitis is probably also due in part to impaired nerve-influence, and in part to slight injury in the passage of a catheter, or to the introduction by the catheter of pyogenic micro-organisms. The urine, which is at first acid, becomes ammoniacal from the conversion of the urea into carbonate of ammonia, and thick from the deposit of phosphates and the presence of ropy mucus. The inflammation may then extend up the ureter to the kidney, where suppuration of the pelvis and substance of the kidney (*pyelo-nephritis*) may be set up.

Such may be taken as a typical example of fracture of the spine as commonly met with in surgical practice. But the nature and gravity of the symptoms will depend upon the situation of the fracture, and the amount of injury to the cord. Thus in some cases of fracture there may be no paralysis; in others the paralysis may be incomplete, *i.e.*, confined to loss of motion only, or to paralysis of one limb or one group of muscles, or to impairment of sensation over some limited area. Such cases, however, are much less common than that above described.

Causes of death.—1. When the fracture is above the fourth cervical vertebra, death is instantaneous in consequence of the severance of the phrenic nerves from the respiratory centre in the medulla. This is especially the case in fractures and dislocations of the atlas and axis. 2. In the lower cervical or upper dorsal region, death is due either to (*a*), hæmorrhage around the cord

gradually extending to the origin of the phrenic nerves, or (*b*), a low form of bronchitis induced partly by hypostatic congestion, partly by defective nerve-influence, and partly by inability to clear the lungs effectually by coughing. 3. Later, death is commonly due to exhaustion produced by (*a*), the sloughing of the bedsores, or (*b*), the pyelo-nephritis, induced in part by the extension of cystitis up the ureters to the kidneys, and in part by the defective nerve-influence on the kidney substance.

The *prognosis* will depend in great measure on the situation of the fracture and condition of the cord. Thus, when the fracture is *in the cervical region*, if death is not instantaneous, the patient may survive from twelve hours to two or three days; usually, however, death occurs in about twenty-four hours. *In the upper dorsal region* the patient may linger for two or three weeks. *In the lower dorsal region*, if he survive the period at which the inflammatory troubles commonly occur, he may recover, remaining, however, if the cord is severely injured, paraplegic. *In the lumbar region* he may recover, with perhaps only partial paralysis of one or other of the lower limbs or of a certain group of muscles, or even without any paralysis whatever. But even where the injury to the cord has been so high as to cause paralysis of the whole body below the neck, patients have been known in rare instances to live for several months or even years.

Treatment.—1. In cases where there is no paralysis, thus showing that the cord is not affected, the indication is to keep the fractured spine at perfect rest, for the purpose not only of obtaining union of the fracture, but also of preventing by any movement displacement of the fragments and injury of the cord. 2. In the more common cases, where there is paralysis, showing that the cord is injured, the indications are to remove any fragments that may be compressing the cord, and subsequently to keep the parts at rest till union of the bones has occurred. 3. Where, however, as is too frequently the case, the removal of the fragments is not practicable, or the cord itself has been crushed, all that can be done is to endeavour to guard against the formation of bedsores, and the occurrence of chronic cystitis and its attendant evils. Thus the patient should be placed upon a water-bed, and his posture gently changed from time to time, so that pressure may not be continuously made on one part, while he must be kept scrupulously clean and dry, and free from urine and fæces. The bowels should be cleared, if necessary, by enemata, or excessive diarrhœa controlled by morphia suppositories or starch and opium injections. Should bedsores (see p. 37) threaten, the skin should be hardened by sponging with rectified spirit, and dusted with oxide of zinc and starch powder. If formed, they should be dressed with mild antiseptics, iodoform, balsam of Peru, etc., and all pressure removed from the surrounding skin by the use of water cushions. To

prevent cystitis from occurring a soft rubber catheter, thoroughly cleansed in carbolic lotion and dipped in glycerine, should be passed twice daily. Should the urine become alkaline the bladder must be washed out with some antiseptic solution, as salol (gr. x. to ʒj.) or boric acid (gr. x. to ʒj.). *Extension and laminectomy.*—In cases where, from the marked inequality of the spinous process, there is a probability of fragments pressing upon the cord, a cautious attempt to extend the spine and reduce the displaced vertebræ may be made, and a plaster-of-Paris case applied during the extension. A partial dislocation of the cervical vertebræ, indicated by partial paralysis, rigidity of the head and irregular bony prominences, has been reduced by combining extension with direct pressure. In some instances it may be justifiable to excise the neural arches (*laminectomy*) for the purpose of removing a fragment of bone, extravasated blood, or inflammatory adhesions or exudations that appear to be compressing the cord. The operation is quite useless where the cord has been transversely divided as shown by complete paralysis of motion and sensation and total loss of both the superficial and deep reflexes. The evidence in favour of the compression being due to blood is that the paralysis was not present immediately after the injury, and is gradually extending higher and higher up the body.

Traumatic spinal hæmorrhage.—As the result of an injury with or without implication of the spinal column, hæmorrhage may occur in the substance of the cord (*intra-medullary hæmorrhage*), or, as is more often the case, around the cord (*extra-medullary hæmorrhage*), the blood then being extra-dural or less frequently intra-dural. Intra-medullary hæmorrhage is usually limited in extent, but generally more or less completely destroys the segment of the cord in which it occurs. When this is the case there is sudden and complete paralysis of both motion and sensation of all parts below the seat of lesion. When the hæmorrhage is limited, the paralysis may be less complete and confined to certain groups of muscles. In the extra-medullary there is commonly an interval between the accident and the onset of the paralysis, as it is only after a certain amount of blood has collected that the cord becomes compressed. As the blood extends up the spinal canal the paralysis increases, till finally the respiratory centre is reached, when death ensues. As the nerves coming off from the cord are gradually pressed upon by the blood, symptoms of spinal irritation, such as pain, hyperæsthesia, and muscular spasms, are set up. These signs are unattended by fever. *Treatment.*—Rest, cold to the spine, and subcutaneous injections of ergotin, may be tried. In the extra-medullary form a laminectomy may, by giving exit to the blood, relieve the pressure on the cord.

Concussion of the spine.—Under this term are included a series of injuries to the spinal column and cord often of an ill-defined

nature, the anatomical lesion remaining in many instances unknown. Attention having been especially drawn to the occurrence of such injuries as the result of accidents on railways, they have been called collectively by some "the railway spine." Frequently, therefore, the subject has been discussed in courts of law, where "expert" medical witnesses have tendered such a partial presentation of the matter as to make the medical evidence appear contradictory.

Various forms of accidents give rise to similar conditions—the sprains already mentioned, excessive extension of the column, jars caused in a railway accident by being thrown forward against the woodwork of the carriage, a fall on the feet from a height, a fall from a horse upon the shoulders or head, the fall of heavy objects on the back, a blow, finally, a bullet passing through or lodging close to the spine.

Anatomical lesions of the spinal cord and meninges may be discovered or not. There may be hæmorrhage without or within the dura, in the substance of the cord or even in the central canal, or the cord may be reduced to a pulp without hæmorrhage. The cord may be bruised or lacerated without the column being injured, or may exhibit a progressive softening and sclerosis. Months after an accident a post-mortem examination may show scattered patches of sclerosis, the result of chronic myelitis, or irregular degeneration and vacuolation in the grey matter and its cells, or the scarring may be confined to the meninges. However, in cases of paralysis after an accident, no lesion of the vertebral column or of the spinal cord has been discovered.

The *symptoms* may be divided into (1) Those which are immediate and severe, arising either from compression by blood and laceration, or from so-called concussion, in which no anatomical lesion is discoverable, the injury resulting in an abolition of function only. (2) Those which are at first comparatively slight, but which increase slowly and gradually after the accident owing to a progressive softening. (3) Those which are absent at first, but which appear after some time owing to a chronic degenerative lesion.

(1) The immediate symptoms may indicate a transverse lesion of the cord at a certain level giving rise to paralysis below, or a partial transverse lesion, or a lesion of particular nerve-roots as of the arm or leg, motor or sensory, or of the sympathetic, *e.g.*, the pupils become unequal. The concussion may influence the cerebrum, *e.g.*, loss of consciousness. Vomiting may also be due perhaps to the same cause, or may be reflex in origin.

The examination must include the mapping out of the sensory and motor nerves affected. The tendon reflexes are variable, being abolished by shock, by destruction of the cord in the lumbar enlargement, or by degeneration especially in the posterior columns. The superficial skin reflexes in the legs are lost only when the lower part of the cord is involved. Prognosis is very uncertain; if the

patient survives the injury and escapes the results of paralysis of the bladder and kidneys, gradual recovery may take place and improvement continue even for several years.

(2) The slight symptoms of numbness, tingling, weakness, stiffness, may follow the accident. These may increase into a paresis or spasms, indicating a subacute myelitis, which may end in paraplegia and death. Thus Sir W. Gowers mentions a case in which no injury was apparent immediately after the accident, but paraplegia set in some days later, and six weeks afterwards at the post-mortem he found subacute myelitis, especially in the white matter.

Tremor, girdle pain, pins and needles, numbness, relaxation of sphincters, trophic changes, paralysis and muscular atrophy, loss of sensation, hyperæsthesia, unsteadiness in gait, or distinct ataxia may appear. Improvement may gradually set in, and if the early symptoms have not been severe, recovery may be complete or some permanent loss of function persist.

(3) Some considerable time after an accident one of the systematic degenerations of the spinal cord sets in, giving rise for example to locomotor ataxia, progressive muscular atrophy, spastic paraplegia, etc. But also there may be evidences of local myelitis and sclerosis, as if some definite injury had been produced at certain spots. It is assumed in such cases that the accident has caused a defective nutrition, the results of which slowly come into view, and which are, in addition, complicated by other conditions which are known to produce the same result, such as syphilis.

Spinal pain or spinal irritation is common to all forms, and may be looked upon as a spinal neuralgia. It may be felt deep-seated at one spot, at the end of the column, occiput or sacrum; or be widespread, slight and vague, or severe. It may be continuous, increased by exertion, mental or bodily, or may give rise to paroxysms.

The *mental disturbance* from an accident may be immediate or gradually develop. It undoubtedly increases the painful sensations, and some patients show various degrees of emotional excitement, often called hysterical. But it is generally more correct to say that the patient's symptoms are real, although exaggerated by the attention paid to them. The shock of the accident, the dread of permanent disability, the confinement and anxiety as to occupation, worry as to obtaining compensation, and the slow progress of legal procedure, all tend to disturb the patient's mind. And when his claims for compensation are settled, doubtless he improves mentally. But it will be found that there is no such sudden improvement as regards the true nerve lesions.

Diagnosis.—To certain symptoms little attention need be paid, inability to concentrate attention, disturbance of vision, loss of sexual power, excessive knee-jerks, also the various descriptions which the patient gives of pain, and his inability to perform voluntary movements. Further, the absence of any particular symptom, commonly named as a

"sign," is of comparatively slight significance, *e.g.*, that a patient's spinal cord cannot be injured because his legs are not wasted. The presence of ankle clonus, paralysis and atrophy of groups of muscles, loss of control of the sphincters of the bladder and rectum, indeed, any positive sign of disease as distinguished from the absence of a common sign, is of great importance, as indicating a lesion and tending to localise its position in the cord. A careful examination of the patient, without prejudice, and with an average amount of common sense, will discover the malingerer, while a knowledge of the subject should prevent hasty assumptions of hysteria.

Prognosis.—If the lesions are not severe enough to end fatally either immediately after the accident, or later as the results of paraplegia, a hopeful prognosis may be given, and the patient may be cheered by the prospect of a steady and gradual improvement going on to complete recovery. But, especially when the symptoms have been almost absent at first, when signs of the commencement of one of the progressive degenerations of the spinal cord is detected, the prognosis becomes gloomy. All that one can hope is that the degeneration may be very slow, or may undergo periods of arrest.

Treatment.—Whenever there is reason to suspect an injury compressing the cord, whether bone, blood-clot, or thickening of the dura, the question of laminectomy may be considered. Otherwise the first treatment is rest, which has often to be of a prolonged character, followed by a change of air. Only when it is quite clear that no changes in the spinal cord are occurring or threatening, and when the symptoms are mainly subjective, such as pain and exhaustion, should the patient be encouraged and stimulated to exertion. In any case, severe exertion must not be incurred, especially in the early days. Pain is relieved locally by counter-irritation. Gowers and Taylor speak strongly of the good effect of the application of the actual cautery to each side of the spine over the site of the myelitis. Narcotics, such as morphine or cocaine locally, should only be used when the pain is very acute, and as seldom as possible.

SECTION VI.

Diseases of Regions.

DISEASES OF THE SCALP.

Parasitic inflammation and ulceration of the scalp.—The most common of these are phthyriasis, caused by the *pediculus capitis;* and tinea tonsurans, or ringworm, due to the *trichophyton tonsurans.* Favus produced by the *achorion Schoenleinii* is now very rare in this country.

Phthyriasis may be recognised by the matting of the hair to the scalp by the dried inflammatory exudation beneath which ulceration is present. The hairs are thickly studded with the ova of the louse (nits) and the lice themselves may be seen on the scalp. The lymphatic glands in the neck are enlarged and may become inflamed and suppurate. *Treatment.*—In slight cases the hair may be well tooth-combed or cut short, scrubbed with turpentine and perchloride lotion. In cases of ulceration the head should be shaved and the scalp washed night and morning with carbolic soap, the ulcers being cleansed and dressed with boracic ointment, and glandular abscesses opened and drained.

Tinea tonsurans, or ringworm, is known by the occurrence of circular, partially-bare patches, the hairs over which, if not lost, are broken off short, and when plucked out the roots show on microscopic examination the spores and mycelium of the trichophyton. The presence of the stubbly hairs serves to distinguish tinea from alopecia areata; in the latter affection, moreover, the patches are quite bare, smooth and shining. As the result of too energetic treatment, a patch of tinea sometimes becomes inflamed, forming a circular, slightly-raised, red area, known as *kerion.* The disease may spread to the eyelids, skin, or nails. It is very catching and most difficult to eradicate when it occurs in a large school. *Treatment.*—In the early stages the application of Coster's paste (iodine with oil of tar or creosote), croton oil, iodide of mercury, or glacial acetic acid may be tried. In chronic cases the scalp should be shaved, and scrubbed night and morning with soft soap and carbolic acid, and then dressed with carbolic ointment (grs. xii. to ʒi.). The diseased hairs may be plucked out with forceps, and the suppurating follicles touched with a probe dipped in pure carbolic acid. It has been proposed to graft hair into the bare patches left on the cessation of the disease, by making a prick and inserting into it a hair pulled out from a healthy spot.

Erysipelas of the scalp may be due to direct inoculation of the specific micrococcus through a distinct wound or a mere abrasion or scratch, or to the extension of erysipelas from a neighbouring part. It is most commonly met with after a septic scalp wound, but it not infrequently spreads from a scab or eczematous excoriation on the face, eyelid, or external ear, or follows upon otitis media with necrosis of the mastoid, or upon purulent rhinitis through the frontal sinuses. *Signs.*—The first sign is the pitting of the scalp, which does not turn red as does the face but is pale and œdematous. It is accompanied by headache, drowsiness, or delirium, with other signs of fever. It may subside or terminate in cellulitis, or spread through the skull to the meninges and set up fatal meningitis. (For *Treatment*, see *Erysipelas*, p. 65.)

Cellulitis and abscess of the scalp may occur above the aponeurosis, between the aponeurosis and the pericranium, and beneath the pericranium.

(1) *Superficial to the aponeurosis.*—Suppuration in this situation is always limited in extent, forming a small abscess covered by a thin layer of epidermis, which is quickly perforated, leaving an ulcerated surface. It is usually due to parasitic infection. A short incision should be made, the cavity wiped out with an antiseptic and the diseased hairs removed.

(2) *Between the aponeurosis and pericranium.* — Here the suppuration, which is generally due to a scalp wound and is usually preceded by an erysipelatous inflammation, spreads widely beneath the scalp, owing to the loose connective tissue presenting no resistance, until the whole scalp is floated up as far as its attachments to the supra-orbital margins, the zygomas and the occipital ridges. Vertical incisions should be made at several points round these margins, avoiding arteries and nerves, drainage tubes inserted, and the cavity under the scalp frequently irrigated.

(3) *Beneath the pericranium.*—Suppuration here is limited by the bony sutures to which the pericranium is attached. It may be set up by an infected scalp wound which has penetrated to the bone; more rarely it may be due to the breaking down of a cephalhæmatoma occurring during birth, or to syphilitic or tuberculous disease of the bone beneath. At times it may be of metastatic or pyæmic origin. Pus in this situation is often difficult of diagnosis, since it is spread in a thin layer under the tense pericranium; but the persistence of inflammatory induration will indicate the necessity of an exploratory incision. The abscess should be freely incised, scraped out, and stuffed with gauze. If the bone is dead it will require removal, and by the use of a gouge if not already loose.

Neuralgia of the scalp (see p. 449).

Rodent ulcer is rarer on the scalp than on the face as a

primary growth, but the scalp is often involved by extension from the face (see p. 150).

Epithelioma of the scalp is not uncommon in a contracted scar such as may occur after a burn, sloughing of the scalp or lupous ulceration. *Treatment.*—Immediate excision is required before the bone is involved, and the area left is covered by a plastic operation or by skin-grafting.

Cysts of the scalp or wens.—*Pathology.*—Although the skin of the scalp has an abundance of sebaceous glands and the secretion becomes dried as scurf or dandruff, yet obstruction cysts are exceptional. The common sebaceous cyst of the scalp is a cyst of new formation, a form of dermoid cyst. The wall of the cyst is composed of stratified epidermis and corium with sebaceous glands but no hair-follicles. The contents are pultaceous or porridge-like (hence the old term *atheromatous cysts*) and have the peculiar odour of sebaceous material; but neither hair nor other epidermal structures are found in them. The cysts are often multiple, appear in several members of the same family, and have a tendency to be transmitted especially through the female line. *Signs.*—The cysts begin as a little nodule adherent to the deeper layers of the skin of the scalp. As they grow the skin is stretched so that the hairs appear far apart, or the hair-follicles atrophy, and the surface becomes thin, bald and glistening. Though remaining attached to the skin the rest of the cyst-wall is well encapsuled, being only connected with the aponeurosis by loose connective tissue. As the cysts increase to the size of a hen's egg or the fist, they tend to slip downwards and become more and more pendulous. If not removed, the wall may become calcareous. The cyst may rupture and the inner surface bulge outwards, forming a raised foul mass of granulations resembling a malignant ulcer, from which, however, it may be distinguished by the absence of induration and glandular enlargement, and the history that it began as a sebaceous cyst. Probably an epitheliomatous change finally ensues if the disease is not treated. If a cyst spontaneously discharges through a small opening, the sebaceous material may become inspissated and form a horn. *Treatment.*—A very small cyst may be punctured and a crystal of nitrate of silver pushed in. A day or so later the wall can be easily dragged out through the puncture. A large cyst may be removed without an anæsthetic, by rapidly transfixing it with a long straight bistoury and cutting upwards. The deepest part of the inner wall is then seized and drawn out, when all the unbroken wall comes away. The wound can be united by sutures or plugged with gauze. Under an anæsthetic the cyst can be easily shelled out through an oval incision, the skin attached to the cyst being removed with it. The excision wound is then completely sutured. It is a mistake to try and dissect off the adherent skin, for the margins are thus so bruised that healing does not occur. If a foul ulcer has formed,

it should be well scraped, or excised freely if there is any suspicion of malignancy.

Dermoid cyst of orbit (see p. 160).

Angiomata or vascular tumours of the scalp.—*Capillary nævi* occur on any part of the scalp, the most important being over the anterior fontanelle. If very small they are best destroyed with the cautery point. If large they should be excised. That over the anterior fontanelle requires a careful dissection, and the operation may be postponed if the nævus is not extending until the fontanelle has considerably closed, so as to shut off the meninges.

Cirsoid aneurysm or aneurysm by anastomosis occurs on branches of the temporal or occipital artery. The tumour is of congenital origin, although it may not cause disturbance until puberty. It consists of a number of dilated, tortuous thin-walled arteries communicating with one another. Between the vessels are fat and fibrous tissue in variable amount. A pulsating tumour is formed which shrinks and loses its pulsation when the artery supplying it is compressed. When large the tumour tends to become pendulous. Ultimately ulceration and hæmorrhage occur, producing anæmia, and if the aneurysm is not removed would end fatally. *Treatment.*—The aneurysm is excised by making a circular incision round it and dividing the vessels between clamp forceps. The blood-supply may be controlled by compressing or ligaturing beforehand the temporal or occipital artery. The gap left may be closed by a plastic operation or be covered by skin-grafts. If the aneurysm is very extensive, the external carotid and other branches supplying it may be tied, and what afterwards remains of the tumour treated by electrolysis, excision and pressure.

Venous or cavernous tumour, or cephalhæmatocele.—This is the rarest vascular tumour. It is composed of large venous spaces communicating with the longitudinal sinus. A soft swelling is formed which gives a bluish tinge to the skin covering it. It is compressible, or even completely reducible, when the hole in the skull may be felt. It refills without pulsation, and has an impulse on coughing, and becomes tense on straining or when the head is low. The tumour may first of all be explored at its margin and large veins communicating with it tied. If it communicates directly with the sinus, it must be rapidly laid open, and the hole communicating with the sinus controlled by the fingers or sponges or by plugs of antiseptic gauze. As much of the tumour as possible is excised, the wound sutured and firm pressure applied over the antiseptic dressing. If the communication with the longitudinal sinus is very free, a preliminary ligature of the longitudinal sinus behind and in front of the tumour may be necessary.

Caries and necrosis of the skull may follow erysipelas,

cellulitis and abscess of the scalp, a septic wound with or without a fracture, or a burn that has destroyed a piece of the scalp leaving the skull bare. It may be of metastatic or pyæmic origin, and it is also caused by syphilitic and tuberculous disease, rodent ulcer, and other new growths. *Treatment.*—The dead bone should be removed with a gouge or chisel as soon as it is demarcated, but previous to this a trephine hole should be made, if there is any sign of pus collecting between the bone and the dura.

Syphilitic disease of the scalp and skull is a tertiary gummatous affection. A single large gumma may cut off the blood-supply from the outer table, or widely infiltrate the bone, or a number of small gummata may attack it at different points, so that the skull after death has a worm-eaten appearance (see Fig. 153, p. 345). Ulcers, sharply cut and circular or with a serpiginous margin, appear on the scalp with bare bone in their floor. As the necrosis extends there is danger of thrombosis in the diplöic veins and venous sinuses, or of the formation of a subdural abscess, and ultimately fatal septic meningitis, or cerebral abscess. At times the dura becomes thickened, giving rise to persistent headache or even epilepsy. The diagnosis during life chiefly rests on the general evidences of past syphilis together with the absence of those of tuberculosis. The dried skulls from syphilitic patients show worm-eaten appearances, necrosis of the outer table, and in places thickening from new periosteal bone and sclerosis of the diploë. When the skull is completely perforated the hole is not filled up by bone, and when necrosis occurs the sequestrum is not invaginated. In some of the specimens preserved in museums the conditions have been made much worse by excessive doses of mercury. Other skulls formerly thought syphilitic are now known to be from subjects suffering from osteitis deformans, or sarcoma or tuberculosis, as described in the next section.

Syphilitic ulcers of the scalp should be treated with large doses of iodide of potassium combined with small doses of mercury and the application of a mercurial or iodoform ointment. When bare bone is exposed, the ulcer should be scraped and gauze kept in contact with it until the surface is covered with granulations, when skin-grafts may be put on. If the outer table is dead, it should be gouged away until vascular bone is reached; eventually the whole thickness of the skull may have to be excised, and if the outer surface of the dura mater is involved, it should be also gently scraped.

Tuberculosis of the scalp and skull.—This is a rare form of tuberculous disease which generally attacks patients who have suffered from other tuberculous lesions, such as lupus, subcutaneous and glandular abscesses and tuberculous bone and joint disease. The family history usually indicates a predisposition to tuberculosis, and ultimately the patient may die of pulmonary or meningeal

tubercle. The disease commences in the bone, as a nodule or tumour beneath the pericranium, which extends towards the scalp and ruptures, leaving a tuberculous ulcer with bare skull for its floor. The ulcers are generally multiple, but tend to fuse with one another. The bone becomes widely infiltrated with caseous tuberculous material, so that it cuts like cheese, or is converted into soft débris mixed with granulations. Beneath the skull, tuberculous collections spread superficial to the dura. Ultimately there is extension, thrombosis of venous sinuses, and infection of the meninges or lungs, which may prove fatal. The *diagnosis* from syphilis is made by the absence of the general signs of syphilis and the presence of those of tubercle. The cheesy carious bone differs from the necrosis set up by syphilis, and there is no tendency to repair. The microscopic examination of the material discharged or scraped may disclose tubercle bacilli, but they are few in number and may be missed. There remains inoculation experiments on animals, or the injection of tuberculin, but practically the clinical evidences are enough for a diagnosis.

Treatment.—It is necessary to remove all the tuberculous disease by scraping and gouging away infiltrated bone until healthy vascular bone is reached. The removal of the diseased skull will allow of any subdural collections being evacuated. The wound is afterwards dressed with iodoform gauze and the patient treated generally against tubercle.

DISEASES OF THE SKULL.

Abnormalities occur owing to early union of sutures along the line of which ridges may form, but this early synostosis appears to result secondarily from arrest in development of the brain within, microcephaly, and not the arrest of brain development from the early synostosis (see *Microcephaly*). Gaps may appear in the lines of the sutures as well as symmetrically on the parietal bones through which the membranes and brain protrude (*meningocele* and *encephalocele*). Wormian bones, by causing sutures where such are not generally present, may simulate a linear fracture at that spot.

Hypertrophy and atrophy of the skull.—*Senile alcoholic hypertrophy* is a thickening of the *inner* table of the skull, which together with the diploë becomes converted into a mass of compact bone (Fig. 309). This thickening differs from that arising in osteitis deformans, where the thickening involves primarily the *external* table and is the result of congestion.

Senile atrophy (Fig. 309) affects chiefly the *outer* table so that the surface of the skull exhibits rounded elevations and depressions. Symmetrical depression, *e.g.*, on the parietal bones, may go down through the diploë to the inner table. The same skull may exhibit also sclerosis and hypertrophy of the inner vitreous table as described

(*a*) *Septic signs.*—These consist of fever of an asthenic or typhoid type. The temperature is variable. It may at first be raised, but, as a rule, gradually falls, and may become subnormal. The pulse is not quickened in the early stages, and in the later stages may become slower as the result of increasing intracranial pressure. The tongue, at first clean, becomes furred, dry, and brown, the breath foul, the complexion earthy, and the features sunken. A subnormal temperature, with a slow pulse, in a patient in an asthenic or typhoid condition, especially if he has otitis media, is very suggestive of cerebral abscess.

(*b*) *Signs of intracranial pressure and cerebral tumour.*—The most frequent sign of general pressure is persistent headache, and, later, drowsiness, passing into coma; but with the exception of headache there may be no symptoms till the abscess suddenly bursts, when signs like those of apoplexy supervene. In the earlier stages of chronic cases the mental symptoms are often peculiar and characteristic. They may be summed up as slow cerebration, want of sustained attention, mental obscuration, tendency to doze, and failure of the patient to apply his strength. The cardinal signs of cerebral tumour, namely, optic neuritis, vomiting, and headache, are variable. Optic neuritis may be present, and may then be slight or well marked, and most pronounced on the side of the abscess. More often it is entirely absent. Vomiting is seldom severe, and perhaps only occurs occasionally after food. The headache is generally present and persistent, and may or may not be referred to the seat of the abscess. When the intracranial pressure increases and the cardio-inhibitory centres become further affected, the pulse rate is still further reduced—it may be to forty or fifty beats a minute or even less, whilst the increasing pressure on the respiratory centres renders the respiration stertorous and gives it a periodic or Cheyne-Stokes character.

(*c*) *Localising signs.*—When the abscess occurs in the frontal or temporo-sphenoidal lobe or in the lateral lobe of the cerebellum there may be no localising signs unless the abscess is large and encroaches upon the speech, sensori-motor, auditory or visual centres, or upon the internal capsule or the peduncle of the cerebellum. The localising signs when the sensori-motor area is implicated have been given under *Injuries of the Brain* (p. 483).

(*a*) *Temporo-sphenoidal abscess.*—When the abscess occurs in the temporo-sphenoidal lobe it may involve the auditory centre and give rise to deafness, especially on the opposite side, but this sign is not of much value, as otitis media is often bilateral and the hearing dulled on both sides. 1. The abscess may press upon nerves at the base of the brain, especially the third, and cause ptosis, or even external squint and dilatation of the pupil of the same side. 2. It may press upon the facial cortex, giving rise to facial spasm or paralysis. It must not be forgotten, however, that

the facial nerve as it lies in the aqueductus Fallopii may be involved in the tympanic suppuration. In the latter case the facial paralysis is complete and on the same side as the lesion, whereas in the former it is on the opposite side and the patient can shut his eye and has not lost his sense of taste in the anterior two-thirds of the tongue. 3. The abscess may by pressure affect the visual area in the occipital lobe, and so impair visual perception in the temporal half of the retina of the same side and the nasal half of the opposite side (*hemianopsia*). 4. The abscess may affect by pressure the sensori-motor area in front, causing rigidity (*monospasm*) or paralysis (*monoplegia*), especially of the arm of the opposite side, the leg and the face being less affected (see Fig. 314). 5. The abscess may press on the internal

FIG. 312.—Large abscess in the right temporo-sphenoidal lobe of the brain, the result of otitis media. (St. Bartholomew's Hospital Museum.)

capsule, giving rise to both sensory and motor paralysis, and affecting first the leg, then the arm, and then the face, or all three simultaneously. In pressure on the cortical area the order of paralysis is the reverse, and there is no anæsthesia. 6. If the abscess is on the left side, the patient may exhibit some form of aphasia from pressure on Broca's convolution. To sum up, if in conjunction with the general signs of cerebral abscess paralysis of the third nerve is present, say on the right side, with spasm or paralysis on the left side beginning in the face and involving the arm to a less extent but not the lower limb, and there is no sensory paralysis, a large abscess in the right temporo-sphenoidal lobe (Fig. 312) may be diagnosed.

(*b*) *Abscess in the lateral lobe of the cerebellum.* — When the abscess is in the lateral lobe of the cerebellum, if the patient is able to walk he may have a staggering gait and a tendency to fall towards the diseased side; if recumbent he may have weakness of the arm and leg of the diseased side, especially of the arm, owing

to the fact that the cerebellum of one side assists the opposite half of the cerebrum. There may be skew deviation of the eyes, the eye of the diseased side being turned upwards and outwards, that of the opposite side downwards and outwards. Or there may be conjugate deviation of the eyes to the opposite side, any attempt to turn the eyes either way resulting in nystagmus (Risien Russell). Optic neuritis and vomiting are more marked than in cerebral abscess, and there may be retraction of the head and pressure on such nerves as the fifth, sixth, auditory and facial. Symptoms of compression usually appear earlier than in abscess of the cerebrum.

The *diagnosis* is often very difficult. It is necessary in the first place to exclude enteric fever or some obscure cause of septic poisoning, such as a chronic empyema, etc., and then to differentiate between abscess, meningitis, sinus thrombosis and mere suppuration in the mastoid antrum and cells. In *meningitis* the temperature is usually high, the pulse rapid, irregular and intermittent, the headache is attended with intolerance of light and sound and general hyperæsthesia, and often with strabismus, spasms and convulsions. In *sinus thrombosis* the temperature is pyæmic in character and associated with severe rigors, the pulse is rapid, and there may be pain or tenderness over the course of the lateral sinus or jugular vein. In *mastoid suppuration* there is usually pain and tenderness over the mastoid, and later swelling and œdema. In many cases, however, the diagnosis can only be settled by an exploratory operation.

Treatment.—Unless this has been done at a previous operation, the mastoid antrum and the tympanum should be carefully explored and thrown into a common cavity by cutting away the posterior wall of the external auditory meatus (p. 661). It may then be found that there is necrosed bone, and this being followed the middle cerebral fossa is opened upwards or the groove of the lateral sinus posteriorly. Any pus that may then be discovered beneath the bone is let out and the cavity drained. If no pus is discovered, the dural elevator is passed a little all round, to determine the presence or absence of an abscess between the bone and dura slightly removed from the opening. If the dura bulges, showing intracranial tension, and if the localising symptoms are fairly well marked, a flap of dura is raised, the opening being enlarged if necessary by cutting more bone away in an upward and forward direction. A subdural abscess may now be discovered, or the brain may bulge and give an increased resistance on palpation with the finger. A full-sized hydrocele trocar should next be introduced into the brain substance, avoiding any large veins that may be seen. Pus may now stream out through the cannula, or simply ooze out when it is withdrawn, or the cannula may have a foul odour if the brain is simply softened. Failing to find the abscess at the first puncture, the trocar and cannula should be passed in all directions within an inch or so of the brain surface.

The point of the trocar should be sharp or it may fail to puncture or may push aside a thick-walled abscess, and the cannula should be fairly large or the pus may not flow. Instead of a trocar a narrow knife may be used. The cavity of the abscess should be very gently washed out with boiled water or a weak solution of iodine, a drain tube or slip of iodoform gauze inserted, and the rest of the wound closed and dressed with antiseptic gauze. If on exposing the middle cerebral fossa the dura does not bulge, and the localising symptoms give no aid, some surgeons before exploring the brain would investigate the condition of the posterior cerebral fossa. This should

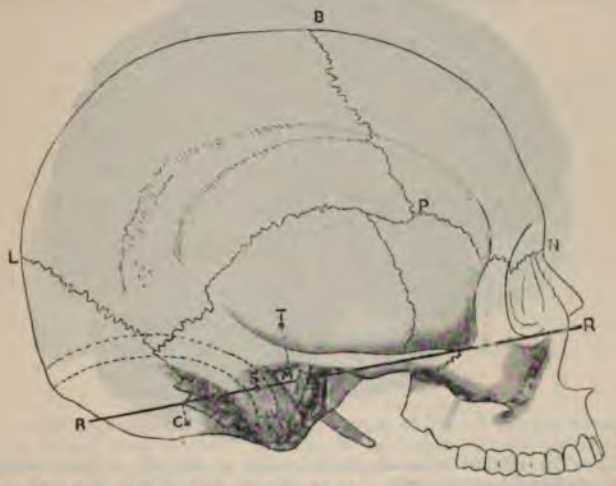


FIG. 313.—Position for exploring for cerebral abscesses and lateral sinus thrombosis. B. Bregma. L. Lambda. N. Nasion. P. Pterion. R R. Reid's base line. M. Macewen's supra-meatal triangle, the position for opening mastoid antrum. S. Position for exposing sigmoid bend of lateral sinus. T. Spot for trephining for temporo-sphenoidal abscess. C. Spot for trephining for cerebellar abscess.

certainly be done if an abscess in the temporo-sphenoidal lobe is not found, and the cerebellum then explored in the same way. If still unsuccessful, either at once or at a subsequent operation the opposite temporo-sphenoidal lobe and lateral lobe of the cerebellum should be similarly dealt with if the otitis media is bilateral, provided always that sufficient cause in the mastoid antrum or lateral sinus has not been discovered to account for the signs of intracranial pressure. The mastoid antrum is best exposed through a curved incision behind the ear. The ear is drawn forwards, the periosteum retracted, and the bone forming the floor of the supra-meatal or Macewen's triangle cut away with a chisel or burr. By chiselling away more bone in a forward and upward direction immediately above the upper margin of the external auditory meatus the middle

of vision. 4. Loss of hearing suggests a lesion of the two upper temporo-sphenoidal lobes. 5. *Amnesia*, sensory aphasia, word deafness or the loss of memory of the sound of a word, indicates a lesion of the posterior half of the first temporo-sphenoidal convolution of the left side. 6. *Alexia*, word blindness or loss of memory of the appearances of a written word, points to lesion of the angular and supra-marginal convolutions of the left side. 7. *Agraphia*, or loss of memory of the muscular movements of writing, suggests a lesion of brain below the motor area or of the posterior part of the second left frontal convolution. 8. *Optic neuritis* on one side indicates a tumour

Fig. 316.—Glioma of brain. (From a specimen in the Westminster Hospital Museum.) The illustration has been kindly lent by Dr. W. Lazarus-Barlow from his Pathological Anatomy. The tumour is favourable for removal in that it is growing from the cortical surface, is circumscribed and of moderate size.

on the same side; if bilateral, a tumour on the side in which the neuritis is most marked. The aid to localisation that may be derived from the involvement of the cranial nerves has already been mentioned under *Injuries of the Head* (p. 477). A sudden increase in symptoms indicates hæmorrhage into or around the tumour.

Where, from a consideration of the above symptoms, a tumour of new growth is believed (Fig. 316) to be fairly circumscribed and in an accessible situation, the skull should be trephined, a sufficient portion of the bone removed to fully expose the growth (see p. 493), and the growth cut away by making perpendicular incisions into the brain around it and raising it by means of a sharp spoon. The removal of a portion of the cortex will be followed by loss of function

of the area removed, but this to a great extent will be regained by the aid of the surrounding areas, especially as regards the coarser movements. The finer movements of the fingers and thumb will not be completely regained; hence in this region the removal of cortex should be as limited as is consistent with success.

Hydatid cysts of the brain are generally acephalocysts containing no heads or hooklets, but only a laminated membrane with no adventitious cyst or practically none. Generally they give rise to the signs of a slow-growing cerebral tumour. There is early headache, which is persistent with paroxysmal exacerbations; it may be local over the situation of the parasite or be referred to some other spot. There is also vertigo and vomiting, optic neuritis causing partial or, if followed by atrophy, total blindness, ataxia, hemiplegia, and paraplegia. Besides the foregoing signs, there may be evidences of a lesion in the sensori-motor area, also a gradual thinning of the skull over the cyst or a separation of sutures until finally the cyst begins to raise the scalp. An hydatid cyst has to be diagnosed from hydrocephalus and from a tuberculous affection occurring in young patients. Cysts have been successfully removed, *e.g.*, from the cortical area and from the cerebellum, and this removal can be done through quite a small opening.

Focal epilepsy, general paralysis, cephalalgia.—In *focal epilepsy*, that is, epilepsy without obvious gross lesion, when the fits become very frequent, for example more than one an hour, and the mental processes are becoming further impaired, the focus in the cortex representing the initial movements may be exposed, the exact spot for the initial movements found by exciting the brain with the Faradic current, and this area of the cortex excised. After such an operation a diminution in the number and severity of the fits as well as an improvement in the health of the patient may be expected. In *general paralysis* trephining in a few cases has been of some benefit in the early stages of the disease. Thus the hallucinations have disappeared and the patient has so far improved as to be fit to be at liberty. In *severe cephalalgia* incapacitating the patient for work or preventing sleep, trephining may give relief. In such cases an exostosis, a spiculum of bone, an enlarged Pacchionian body, or a fibrous tumour or cyst of the dura mater has been found, and its removal has been followed by complete recovery. In other cases where a tumour, etc., of the brain which did not permit of removal has been discovered, the relief of pressure has freed the patient from the excessive pain or threatened blindness.

Hydrocephalus, especially (*a*) when accompanied by fits, (*b*) when progressive atrophy of the optic nerve threatens, or (*c*) when dementia or coma supervenes, may be treated by tapping the ventricles at intervals and applying slight pressure to the skull, or if this fails, by continuous drainage of the ventricles. Attempts have been made, but without much success, to drain the ventricles

into the sub-arachnoid space by introducing a strand of catgut or kangaroo-tail tendon through the brain substance, an end in each situation.

Microcephaly combined with idiocy, due it was tho some cases at least, to too early synostosis of the cranial especially the sagittal and coronal, was treated by crani *i.e.*, the removal of a strip of bone on either side of the mid of the skull. The aim of the operation was to allow the br development of which was thought to be prevented by th synostosis, to expand. In some of the cases reported, th of the child continued to develop after the operation. condition of the skull is now generally held to be secondar arrested development of the brain. The operation has dangerous from the weakly character of the patient, and no i ment appears to have followed operation more than can be o by a suitable education.

DISEASES OF THE EAR.

By A. E. Cumberbatch, F.R.C.S., Aural Surgeon to St. Bartholomew's Hospital.

Physical examination of the ear.—In making an exam of a patient, let him be seated between the surgeon and the of light, with the affected ear towards the examiner. Thr

Fig. 317.—Aural specula.

light on the ear with the mir notice any abnormal condition auricle or the external meatus. grasp the auricle between the and index fingers, the speculu 317) between the index fing thumb, and pulling the auricle u and backwards, insert the speculum with a gentle rotatory ment. Any epithelium or wax that may obstruct the view sh removed by means of forceps (Fig. 318), or the syringe. canal be unobstructed, the membrana tympani can be seen ing across its deeper part as a delicate bluish-grey or yellowi semi-transparent and highly polished film. Near the upp anterior margin is a whitish prominence—the *processus brev* running downwards and backwards from this, to a point just the centre of the membrane, is the *handle of the malleus.* Fr tip of the handle a cone of light extends downwards and fo with its base to the periphery. From the processus brev indistinct lines extend backwards and forwards—the *anter posterior folds.* If the membrane be very thin or its p segment much retracted, the *long process of the incus* can b posterior to and parallel with, the handle of the malleus. portion of membrane above the anterior and posterior folds i

Shrapnell's membrane, and consists only of the dermoid and mucous layers. Whilst noting these points, carefully search the membrane for perforations, opacities, or small polypi. After thus inspecting the membrane, its mobility should be ascertained by means of 1, the

Fig. 318.—Aural toothed forceps.

pneumatic speculum, or 2, by forcing air into the tympanum through the Eustachian tube, either (*a*) by Valsalva's method, (*b*) by Politzer's method, or (*c*) by the catheter.

(*a*) *Valsalva's method* consists in making forcible expiration with the nose and mouth closed.

(*b*) *Politzer's method.*—Direct the patient to take a mouthful of

Fig. 319.—Politzer's insufflator.

water; insert the end of the india-rubber tube into one nostril, carefully close the unoccupied portions of this and the other nostril with the index finger and thumb; tell the patient to swallow, and sharply compress the bag (Fig. 319). In small children the tympanum can be inflated without their drinking water. Some patients find a difficulty in swallowing easily when told to do so;

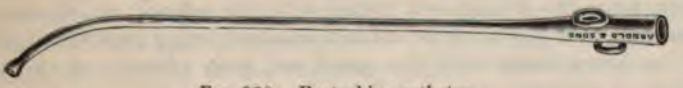


Fig. 320.—Eustachian catheter.

such persons should be made to say some guttural word such as "Huck," or distend their cheeks with air.

(*c*) *To pass the Eustachian catheter* (Fig. 320), hold the instrument lightly between the forefinger and thumb and pass it quickly along the floor of the nose, keeping the point of the instrument downwards till it reaches the back of the pharynx; next draw it forward about three-quarters of an inch, gently rotating outwards at the

so limited a space. To complete the examination of a patient, test his hearing by means of the watch and voice, and finally examine the naso-pharynx in cases where there is reason for suspecting that an unhealthy condition of these parts may be the exciting cause of the ear-mischief.

I. **Diseases of the external ear:—Eczema** may be acute or chronic; primary, or secondary to eczema of the head. In the *acute form* there is great redness and swelling of the auricle; it is hot, tense, and tender, and later a crop of vesicles appear which exude a serous fluid soon drying into crusts; these, when they fall off, leave a raw surface. Acute eczema rarely invades the meatus. The *chronic variety* may attack the whole auricle; more frequently it is limited to some part of it. There is little or no redness, the surface is dry and scurfy, and fissured in places, and the disease generally spreads into the meatus, and sometimes even to the drum-membrane. In such cases there is more or less deafness, accompanied, it may be, by tinnitus, and a stuffy feeling in the ear. *Treatment.*—In the acute stage apply lead and opium lotion, or powdered zinc and starch in equal parts; later, useful applications are linimentum calcis, or ung. hydrarg. subchlor. (ʒj. ad ℥j.). If the parts continue red and swollen, paint them with argenti nitratis (ʒss. ad aq. f℥j.), and then apply powdered boracic acid, or ung. hydrarg. oxidi. rub. (gr. ij. ad ʒj.). Applications to the meatus must be applied with a small brush; the parts should be washed with oatmeal instead of soap. *Constitutional treatment* must not be neglected.

Hæmatoma auris may occur spontaneously or as the result of an injury as in boxing or a kick at football, and is not uncommon among the insane. It consists of an effusion of blood between the cartilage and perichondrium on the anterior surface of the auricle. It occurs as a hard and rarely fluctuating swelling, varying greatly in size. The skin over it is of a more or less livid hue, but occasionally is hardly discoloured. There is a feeling of warmth or tingling, but rarely of pain. After a time it gradually becomes smaller and may entirely disappear. Sometimes it forms a cyst or suppurates. In the end the auricle is left more or less deformed. *Treatment.*—At first the application of ice or cooling lotions; some recommend tapping it and injecting iodine; others laying it open and dressing it with a weak solution of carbolic or boracic acid. Of course, if it suppurates, it must be opened freely. A puckering of the ear then results.

Malformation of the auricle is due to arrest of development of the hyomandibular arch including Meckel's cartilage. The auricle retains the form existing in the early fœtus, the external and middle ear are ill-developed and communicate with the pharynx by a mere sinus representing the Eustachian tube, whilst the vertical and horizontal rami of the jaw present a flattened aspect.

Outstanding ears.—The auricles may be thin and projec
right angles to the head, or even be doubled over at the ti
dog's ear. *Treatment.*—An elliptical piece of skin may b
out from the back of the auricle so as to allow of its be
back in proper position.

Sebaceous cysts are not uncommon.

A pendulous lobule and even a fibrous mass may res
wearing irritating earrings.

Both **rodent ulcer and epithelioma** may destroy th
in old men, and require an early excision.

II. **Diseases of the meatus:—Diffuse inflammation**
by injury, irritants (such as scratching the meatus with
sea-bathing. There is redness and swelling of the skin li
meatus, a sense of fulness, and throbbing and occasional
followed by serous or semipurulent secretion. After a
epithelial lining becomes whitish and sodden, and, on s
comes away in flakes, or even as a cast of the meatus, les
surface beneath red, and frequently obliterating the de
between the meatus and tympanic membrane. Rarely the
membrane may be perforated. There is pain, increased
ments of the jaw or pressure on the auricle, and sometin
Treatment.—In the early stages cold compresses, and a lee
to the tragus; and antiphlogistics. As soon as secretion
lished, instil a warm solution of boracic acid, and later eq
of alcohol and water, or blow in powdered boracic acid.
charge prove obstinate, the surface may be painted with
of nitrate of silver (ʒss. ad. fʒj.), or liquor plumbi subacet

Furuncles.—Small boils frequently occur in the meatus
anæmic, and diabetic patients; also in those exposed to ba
or whose nervous system has been greatly taxed. Th
begins with pain, often of the greatest intensity, radiating
side of the head and increased by movements of the j
slightest pressure on the auricle. There may be deafne
result of closure of the meatus, not otherwise. Examinati
little or no redness, but one or more swellings, often c
meatus. These are exquisitely tender when touched. A
the abscess bursts the pain subsides, but very often or
after another forms, till the patient's life becomes a burde
through pain and sleeplessness. *Treatment.*—Apply hot
tions, a leech or two to the tragus, and instil a concentr
tion of boracic acid in alcohol. Often a plug of cotton-wo
in glycerine and laudanum, or laudanum, tincture of bellad
cocain equal parts, and gently inserted into the meat
aural forceps shown at Fig. 321, or Gruber's medicate
bougies, give relief. When the abscess is fully formed,
but not before, as early incision is excessively painful and
temporary relief. The general health should be attend

full doses of opium given to procure sleep. Von Tröltsch recommends arsenic to prevent the recurrence of furuncles, or sulphide of calcium may be given.

Impaction of cerumen or wax may be caused by changes in the configuration of the meatus, cleaning the ears with the end of a towel or ear-pick, the presence of a foreign body (such as a piece of cotton-wool inserted into the meatus and forgotten), and by alteration in the character of the secretion so that it is not easily removed by movement of the jaw, etc. The chief *symptom* is partial or complete deafness, generally coming on suddenly. There may be tinnitus or even giddiness, often persistent cough, rarely pain. Sometimes the impaction of cerumen is really due to a peculiar laminated desquamation of the skin of the meatus, which becomes mixed with wax, and thus forms a plug. *Treatment.*—If the wax be not very hard it can be at once removed by syringing with warm water, the auricle being pulled backwards and upwards, and the nozzle of the syringe directed along the upper and posterior wall. If any difficulty be experienced in removing the wax owing to its hardness, soften it first by dropping into the ear for a few nights a

Fig. 321.—Aural forceps.

warm solution of bicarbonate of soda (gr. x. ad f℥j.). After removal gently dry the meatus with a cone of absorbent wool, and let the patient keep a piece in the meatus for a few hours.

Otomycosis is a chronic inflammation of the external auditory meatus due to the presence of a vegetable fungus. It is much more common in India than in this country. The chief varieties are *Aspergillus niger*, *flavescens*, and *fumigatus*. The *symptoms* are a sense of fulness, tinnitus and occasional vertigo, more or less itching, and occasionally pain. On examination there is seen a slight serous discharge, and the meatus is more or less filled with masses of desquamating epithelium, which on removal resemble pieces of damp blotting-paper covered with black or dark yellow spots, while the dermis beneath is seen to be reddened and occasionally bleeding. Microscopical examination of the flakes at once reveals the parasitic nature of the disease.

The *treatment* consists in frequently syringing with a warm solution of perchloride of mercury (1 in 1,000), or chlorinated lime (gr. ij. ad f℥j.), or hyposulphite of soda (gr. iv. ad f℥j.), and, when the meatus is thoroughly freed from the flakes, instilling alcohol.

Aural exostoses may roughly be divided into the spongy and the ivory.

(*a*) The *Spongy* are single and generally pedunculated, are commonly found at the junction of the cartilaginous and meatus, are rapid in growth, follow suppuration of the middl and are frequently the result of ossification of granulations. *ment.*—They can generally be removed by seizing them with of forceps and breaking them off.

(*b*) *The Ivory exostoses* or rather *hyperostoses* may be single, are more often multiple. They vary from ridge-like elevations rounded tumours with broad bases; they are found near the of the meatus, more or less blocking up the canal, and grow slow Syphilis, gout, irritation of the meatus, and sea-bathing are said be the *exciting causes*. *Diagnosis.*—At first sight an exostosis m be mistaken for a polypus, but it can easily be distinguished by hardness, its rounded and polished surface, and, in the case of ivory one, by its extreme sensitiveness to touch. In addition it not moist, while a polypus is. *Treatment.*—They should not interfered with unless they cause deafness by completely cl the meatus, except in those rare cases where they are associat with discharge. In such cases, as they greatly lessen the lumen the canal they should be removed to avoid the risk of pent matter. When their removal is necessary, this should be d through the meatus by means of a chisel and hammer, or the dr drill. Sometimes their removal is facilitated by turning the aur forwards by an incision between it and the scalp so as to f expose the exostosis to view.

Earache may be occasioned by disease of the outer ear, wa foreign body, boil or catarrh; by disease of the middle ear; disease of the nose, such as nasal obstruction; by pharyn affections, such as inflammation of the tonsil, malignant disea the distribution of the glosso-pharyngeal nerve; by carious to and by general causes, such as anæmia. *Treatment.*—It ma temporarily relieved by dropping in hot water, almond oil, tincture, a 10 or 20 per cent. solution of the glycerine of carb acid, or a 20 per cent. solution of cocain, or by applying vapour, or hot belladonna or poppyhead fomentations. But cause of the earache should be made out as soon as possible.

III. **Diseases of the middle ear:—Acute catarrh** ma started by any condition which produces acute naso-pharyn catarrh, such as a severe cold, the exanthemata, etc. It may be caused by sea-bathing, or by the use of the nasal d *Symptoms.*—The attack begins by a feeling of fulness in the h followed by pain, which varies in character from a dull aching severe throbbing or stabbing; there is more or less deafness sometimes tinnitus, and even giddiness, and in severe cases disturbance. On examination, the membrane shows at fi little change beyond a slight loss of lustre, and the presen fine streak of red along the posterior edge of the malleus

In severe cases, the posterior segment of the membrane and the adjacent meatus are red, and this redness may spread over the entire membrane till the outline of the malleus-handle is lost. Vesicles and even small abscesses may form on its surface. Later the epidermis is loosened in white flakes, and finally the membrane distinctly bulges, when the effusion of fluid is great. The Eustachian tube is closed by swelling of its lining membrane. After some days, varying with the severity of the inflammation, resolution begins, or the fluid (mucus or pus) bursts through the membrane, and is discharged into the meatus. *Treatment.*—The patient should be confined to the house, or even to his bed, according to the severity of the attack. An aperient should at once be given, and an astringent gargle. If the pain is severe, a leech or two should be applied to the tragus. Cold compresses should as a rule be avoided, but hot fomentations are grateful to the patient and generally useful. The ear may also be gently syringed with some warm antiseptic lotion. If there be distinct bulging the membrane should be incised, especially if the pain persists. If there be any tenderness over the mastoid this should also be leeched. After the severity of the symptoms has subsided, the tympanum may be inflated daily by means of the air-douche, if necessary, and if the discharge continues, the ear syringed with a warm solution of boracic acid (1—10) night and morning, and a lotion of sulphate of zinc (gr. v. ad f℥j.), or equal parts of rectified spirit and water instilled; or after syringing with warm water and drying the meatus with absorbent wool, powdered boracic acid may be blown in. If the catarrh is non-purulent the membrane is rarely perforated; and even if perforation occurs, the aperture speedily heals after the escape of the fluid. Inflation by means of Politzer's bag should be continued with decreasing frequency till the hearing is restored.

Chronic purulent catarrh (popularly called *Otorrhœa*), follows the acute form of disease. After freeing the ear from discharge, the membrane appears thickened and yellowish, from the presence of sodden epithelium, or if this has been removed, reddish in hue. In some part of it a perforation can usually be detected varying in size, the margins granular or clean cut. If large, the lining membrane of the tympanum can also be seen, varying in colour from pale pink to dark red, according to the degree of inflammation present. When very small and situated anteriorly the perforation sometimes cannot be seen, but its existence can be proved by inflating the tympanum and listening with the diagnostic tube. The amount of deafness present in chronic purulent catarrh varies greatly. There is rarely tinnitus, but giddiness is far from uncommon. It is in this form of disease that patients are specially liable to the complications which will be considered later. *Treatment.*—After attention to the general health, the most important

part of the treatment is great cleanliness. If a quantity of half-dried secretion mixed with epithelial débris be found in the meatus, this should first be removed by the instillation of warm bicarbonate of soda (gr. x. ad f℥j.) for several nights, and then thoroughly syringing the ear. Next let the ear be syringed with warm boracic acid night and morning, and after drying the meatus blow in powdered boracic acid. If this treatment be unsuccessful, then try an alcoholic solution of boracic acid (boracic acid grs. x, alcohol ℥j.); or if this causes pain, the solution may at first be diluted with an equal quantity of water. Or sulphate of zinc (gr. x. ad f℥j.), or acetate of lead (gr. iij. ad f℥j.) may be tried.

If the perforation be large and the mucous membrane of the tympanum much swollen it should be touched with solid nitrate of silver, or a saturated solution of chromic acid or liquor ferri perchloridi. If, in spite of all treatment, the discharge persists, is offensive, and the presence of granulations point to the probable existence of carious bone, the mastoid antrum must be opened and the outer wall of the aditus and attic removed, so as to throw the antrum, attic, and tympanum into one cavity.

Fig. 322.—Forceps for inserting artificial drum.

Often when the discharge has ceased, the membrane remains perforated, and there is considerable deafness. In such cases the hearing may be greatly improved by means of an *artificial membrane*.

Without here discussing how the artificial membrane acts, it is sufficient to say there are two kinds, known as Yearsley's and Toynbee's. 1. *Yearsley's* consists of a piece of moistened cotton-wool, rolled into an elongated plug, and applied with a pair of forceps specially designed for the purpose (Fig. 322). 2. *Toynbee's* consists (Fig. 323) of a disk of soft india-rubber with a piece of silver wire attached to the centre. The former has the advantage of being less irritating to the ear, and can be moistened with medicated fluids, should any discharge still persist, but it has the disadvantage of being more difficult to apply. Toynbee's is easily applied, but it is more irritating to the ear. There are various modifications of Toynbee's, the best being *Gruber's*. It is impossible to tell in any given case whether the artificial drum will succeed; this can only be ascertained by trial. When successful the artificial drum should only be worn at first for a few hours. The length of time should gradually be increased as the ear becomes accustomed to its presence. It should always be removed at night.

Attic disease is the name given to purulent catarrh of the upper and posterior part of the tympanic cavity, which is practically cut

off from the rest of the cavity by the projecting ridge of the aqueductus Fallopii, the upper part of the malleus and incus, and a fold of mucous membrane (Fig. 311, A and A^1). Posteriorly the attic communicates freely with the mastoid antrum. Although purulent catarrh of this cavity is usually part of a general catarrh of the tympanum, a very slight inflammatory swelling of its mucous lining may shut it off completely from the rest of the tympanum, and the retained matter escapes through Shrapnell's membrane. The discharge often persists after it has ceased in the general tympanic cavity, and, if long continued, as it frequently is, a small polypus appears through the perforation in Shrapnell's membrane. Continued discharge often leads also to caries of the head of the malleus or incus, and to the formation of caseous masses (*cholesteatoma*). The *treatment* is the same as for purulent catarrh of the general tympanic cavity. If the discharge is obstinate, the cavity may be thoroughly cleansed by means of the intratympanic syringe, or it may be advisable to remove the malleus and incus, especially if either of these bones be carious. By so doing plenty of room is afforded for thorough irrigation of the cavity. If the inflammation extends to the mastoid cells the mastoid antrum must be opened and the attic carefully scraped.

FIG. 323. — Toynbee's artificial drum.

Various *complications* may arise in the course of chronic purulent catarrh. These are—1, polypi; 2, mastoid disease; 3, caries and necrosis; 4, meningitis and intracranial suppuration; 5, phlebitis and septicæmia; and 6, hæmorrhage.

(1) **Polypi** may grow from the tympanic membrane, the meatus, or the tympanic cavity. Those growing from the meatus are not true polypi; but for brevity they will be all classed under the name of polypi. They vary much in size, being sometimes not larger than a mustard seed, at other times large enough to project beyond the external orifice of the meatus. They are usually bright red in colour, but may be pale pink, and when very large greyish-yellow. They bleed more or less readily when touched. The diagnosis is easily made, but care must be taken not to mistake a swollen and vascular membrane for a polypus. In case of doubt, the mobility of the latter, when touched with a probe, will settle the point. *Treatment.*—Polypi growing from the tympanic membrane should be destroyed with a saturated solution of chromic acid or perchloride of iron applied by means of a piece of cotton-wool twisted round a fine pair of forceps (Fig. 321). When the growth springs from the meatus, and is not too far in, it can easily be pinched off with a pair of aural forceps; when deeper in, it can be scraped off with a small sharp spoon. Those of larger size, especially when arising in the tympanic cavity, should be removed by the snare (Fig. 324). If

ear must be syringed twice a day with some warm ant
and alcohol dropped into the meatus and retaine
minutes.

(2) **Mastoid disease.**—Not unfrequently inflam
tympanum spreads to the mastoid cells, especially
irregular cells (*mastoid antrum*) situated just behind
above the external auditory meatus. Its *course* varies
In mild cases the inflammation is superficial, and re

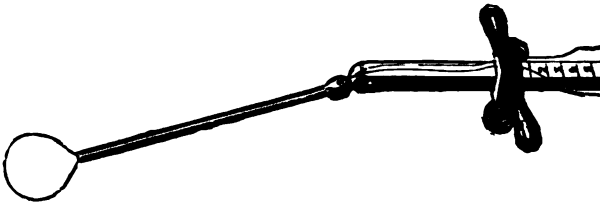


Fig. 324.—Polypus snare.

takes place, or if more chronic there may be gradual
the inflammatory products, and conversion of the
into solid bone. More often there is suppuration,
less softening and breaking down of the bony tra
cells, and the formation of granulation tissue. A
progresses perforation of the bony walls occurs, mo
on the surface of the mastoid process. The matter,
travel upwards or backwards, and may burst into
posterior fossa of the cranial cavity. If the matter
inner side of the apex of the mastoid process into
fossa it burrows down beneath the deep cervical f

than when it is superficial. Sometimes, especially in more chronic cases, the symptoms are very obscure, there being little indication of the mischief beyond deep-seated pain, tenderness on firm pressure, and some fever. It is in such cases that the inflammation is apt to spread to the cranial cavity.

(3) **Caries and necrosis.**—The parts of the temporal bone most frequently attacked are, the mastoid process, the posterior wall of the meatus, and the roof of the tympanic cavity (*tegmen tympani*). It is generally easy to make a diagnosis, but when the deeper parts are affected it may not be possible to do so with certainty. The points that will help the surgeon are, facial palsy, the persistence of offensive discharge in spite of cleanliness, and granulations resisting all attempts at destruction. Even then it may be necessary to put the patient under an anæsthetic, and carefully examine with a probe.

(4) **Meningitis and intracranial suppuration.**—Although meningitis may supervene in the course of acute purulent catarrh of the middle ear, it is generally in the course of the chronic disease that it arises. Intracranial suppuration may occur between the dura mater and the bone—*subcranial abscess*—or in the cerebrum or cerebellum. Subcranial abscess is generally found on the roof of the tympanum or on the posterior surface of the petrous bone; cerebral abscess in the hinder part of the middle temporo-sphenoidal lobe; cerebellar abscess in the anterior part of the lateral lobe. For symptoms and treatment, see *Cerebral Abscess*, p. 657.

(5) **Phlebitis and septicæmia.**—Phlebitis of the lateral sinus may supervene in the course of suppuration of the middle ear, especially when there is caries of some part of the tympanic walls. The signs, diagnosis, and treatment are given under *Infective Sinus Thrombosis*, p. 654.

(6) **Hæmorrhage.**—Slight hæmorrhage is not uncommon from the granulations. Severe venous hæmorrhage may come from a communication with the lateral sinus, and be controlled by plugging the meatus. Severe arterial hæmorrhage uncontrollable by pressure is the result of ulceration spreading from necrosed bone to the internal carotid artery where it gives off the carotico-tympanic twig before making its curve forwards. It has been arrested by ligature of the common carotid artery by Spencer and others, but may prove fatal when the wall of the artery is perforated.

Treatment of purulent otitis and of mastoid disease.—In the early stages hot fomentations and leeches were formerly applied to the mastoid process until pus could be detected by fluctuation. This method has been superseded by an early mastoid incision. For the more chronic conditions a prolonged course of syringing and insufflation of boric-acid powder was employed. Unless improvement quickly follows the measures mentioned on p. 675, and under *Polypi*, a more or less complete mastoid

operation is required to arrest the caries and avoid grave or fatal complications.

Stacke's operation consists in throwing the antrum, attic and tympanum into one cavity. A curved incision is made about a quarter of an inch posterior to *the fold behind* the auricle, which is drawn forwards and the suprameatal triangle (Fig. 313, M) exposed. The bone is removed by a gouge, or mallet and chisel, small trephine, or electric burr, taking away the hinder and upper wall of the meatus until the antrum is reached. The outer wall of the

Fig. 325.—Photograph of the under surface of the upper half of the temporal bone divided by a horizontal section running through the external and internal auditory meatus. (From Rudinger's Atlas.) 20, External auditory meatus. 21, Membrana tympani. 22, Promontory. 23, Stapes on inner wall of the tympanum. 24, Carotid canal. 25, Vestibule. 26, Cochlea. 27, Internal auditory meatus.

antrum may be a mere shell, or be half an inch or so thick, and composed of densely sclerosed bone. All granulations and diseased bone are carefully removed, avoiding the lateral sinus behind, if this be healthy, also the ridge of vitreous bone enclosing the facial nerve in the aqueduct of Fallopius, also the carotid canal close to the commencement of the Eustachian tube. If the caries involves the wall of the aqueduct, great gentleness must be used not to damage the facial nerve, which if touched causes the face to twitch. Then a curved incision is made downwards through the cartilaginous wall of the meatus, outwards and upwards through the concha towards the commencement of the helix, and the conchal flap of skin, from which

the cartilage may be dissected off, is attached to the under surface of the skin flap (see Fig. 326). The mastoid operation as completed according to Mr. Ballance's method leaves a cup-shaped cavity (Fig. 326), formed from the tympanum, attic and antrum, which after being curetted until every scrap of lining membrane is removed and there is only bone, is treated with an antiseptic and dried. It is then filled with a ribbon of iodoform gauze, the end of which is brought out through the meatus, the meatal orifice having been previously enlarged to admit a finger by the turning back of the conchal flap. The cutaneous flap is finally stitched back accurately into position. The gauze is pulled out a little every day, and

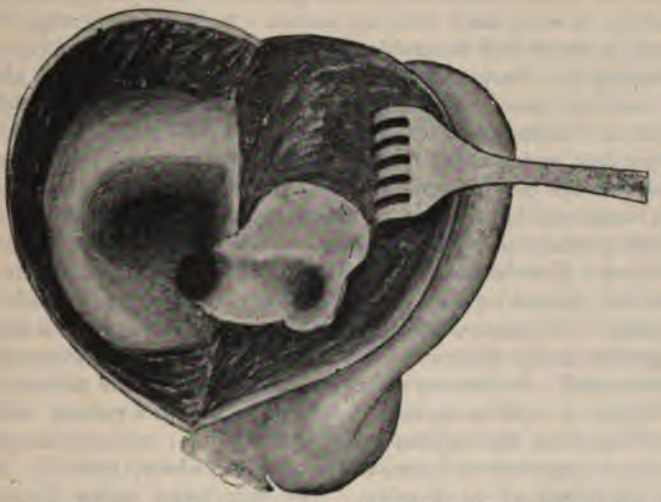


FIG. 326.—Ballance's complete mastoid operation. (Copied, by kind permission, from Mr. Ballance's paper in the "Med. Chir. Trans.," Vol. LXXXIII.) The tympanum, attic and mastoid antrum have thrown into a common cavity, and a flap from the concha has been turned back and fixed to the skin flap.

when it is all removed the bone cavity is seen (Fig. 326) covered with vascular granulations. The anterior wall of this cavity is formed by the epidermal surface of the conchal flap, and with dressings applied daily through the meatus the epidermis may spread over the granulations. But whenever the cavity is at all large, this process should be hastened by grafting. Grafts have been carried in through the widened meatus, and applied to the granulations. But the surer way is to turn forwards again the cutaneous flap, one to three weeks after the first operation, when the bone has become covered with vascular granulations, and then to line the cavity with an epidermal graft (see p. 39). Upon this graft apply a layer of thin gold foil, to prevent the graft being detached, or repack the cavity with a ribbon of iodoform gauze, which, as it

deaf with one ear. The giddiness sooner or later passes off, but the tinnitus and deafness persist. If the deafness is absolute, the tinnitus may eventually disappear. *Treatment.*—Quinine, bromide of potassium, subcutaneous injections of pilocarpine, and electricity are recommended; but all treatment directed towards restoring the hearing is generally useless.

Auditory vertigo is characterised "by a sensation of motion referred by the patient either to himself, or to surrounding objects, which seem to revolve in certain defined planes" (McBride). The attacks are generally paroxysmal, but often there is more or less constant giddiness, with occasional exacerbations. As may be seen above, auditory vertigo is a prominent symptom in Menière's disease, but many causes may give rise to the symptom, such as (*a*) increased pressure on the secondary membranes of the tympanum induced by accumulations of wax in the meatus, forcible syringing, or retraction of the membrana tympani due to obstruction of the Eustachian tube; (*b*) fluid accumulations in the tympanic cavity; (*c*) vascular and nervous changes, or effusion and secondary formations in the labyrinth itself; (*d*) intracranial lesions; (*e*) dyspepsia, and (*f*) such drugs as quinine and salicin. *Treatment.*—The treatment consists in finding the cause, if possible, and attempting to remove it. When this is impossible, large doses of bromide of potassium, alone or combined with hydrobromic acid, will be found most efficacious. Next, quinine in large doses, but this must be carefully watched; and lastly, the use of the continuous current of electricity.

Tinnitus aurium arises under most varied conditions. The sounds complained of are very numerous, but may be divided into ringing, rushing, bubbling, and pulsating sounds. Any abnormal condition of the auditory apparatus will produce it, such as—1, accumulations of wax pressing on the drum-membrane; 2, increased intra-labyrinthine tension, from undue pressure on the fenestræ (either by fluid in the tympanum or retraction of the membrana tympani through obstruction of the Eustachian tube); or lastly, hyperæmia of, or pathological change in, the labyrinth. But in addition to these local causes tinnitus may be produced by causes acting at a distance, such as anæmia, chlorosis, pulsating exophthalmos, aneurysm of the vertebral artery, cerebral disease, large doses of quinine, or salicin. *Treatment.*—In every case it is important, if possible, to ascertain whether the cause is to be found in some derangement of the auditory apparatus or elsewhere. If the cause be local, it is generally possible to relieve or cure the tinnitus by curing the local affection. If the tinnitus depends on general anæmia, some form of iron, with a generous diet and the addition of stimulants may be sufficient to effect a cure. If there be hyperæsthesia of the nervous system, the bromides are indicated, with the addition of hydrobromic acid if the singing is of a pulsating

character. Tinnitus frequently occurs in patients of a rheumatic diathesis, and in such, anti-rheumatic treatment is, of course, indicated. Other remedies failing, the surgeon empirically, may try chloride of ammonium, nitrite of soda, and lastly, the continuous current of electricity.

DISEASES OF THE EYE.

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Physical examination of the eye.—For the complete and thorough examination of the eye it is necessary that it should be examined:—(1) by the unaided eye with or without focal illumination; (2) by the ophthalmoscope; (3) for acuteness of vision, fields of vision, colour sense, and tension. In all cases where practicable each observation on the one eye should be repeated on the other for sake of comparison.

(1) *Examination by the unaided eye with or without focal illumination.*—Seating the patient in front of a window, or in a dark room with the lamp to his left and about two feet in front of him, direct and concentrate the light on his eye by a biconvex lens of about 3 inches (13 D) focal length (*focal illumination*). First look at the *lids*, and tell him to open and shut them; then, with the lids open, to execute the various complete in, out, down and up movements of the eye to test the extrinsic ocular muscles. Along the edges of the lids look for the puncta which ought to be applied close to the ocular conjunctiva. Press near the inner canthus over the lachrymal sac to see if any discharge passes through the puncta. Evert the upper lid to examine its conjunctival surface by directing the patient to look down to the ground, laying a probe horizontally on the external surface of the lid and then taking hold of the lashes turn the lid over the probe. Pull down the lower lid to examine its conjunctival surface.

The ocular *conjunctiva* should be transparent-looking and a few small vessels should be seen through it perforating the white or bluish sclerotic. Just external to the inner canthus is a small greyish-red projection, the *caruncle*, and extending from it a pinkish fold, the *plica semilunaris*.

The vessels seen in inflammations of the eye may be divided into the following:—1. *The posterior conjunctival.* These are generally scarlet or brick-red in colour, tortuous, moveable with the conjunctiva, and do not disappear on pressure. 2. The *sub-conjunctival* are branches or radicles of the anterior ciliary vessels and are divided into the *perforating* and the *episcleral.* The *perforating* arteries stop about $\frac{1}{10}$ inch from the corneal margin, and are well seen in glaucoma; the *episcleral* vessels form a pink zone of straight parallel vessels (*circumcorneal zone*) disappearing on pressure, and

are well marked in iritis and keratitis; the *episcleral veins* are dark, dusky-looking, often in limited patches, and are found in cyclitis, scleritis, glaucoma, etc. 3. The *anterior conjunctival* vessels are superficial branches of the anterior ciliary. They are bright red in colour, found near the corneal margin, and indicate superficial corneal mischief.

Next examine the *cornea*, the depth and contents of the anterior chamber, and the *iris* as to its colour, polish and pupillary aperture.

The normal *pupil* is from 3·5 to 5 mm. in diameter, circular, regular, slightly to the nasal side of the centre of the cornea, and equal to and varying with its fellow under different degrees of illumination. The pupil should contract:—on light being thrown into the same eye (*direct light reflex*), on light being thrown into the opposite eye (*consensual light reflex*), and on accommodation or on the convergent movements of the eye associated with accommodation (*accommodation reflex*). It should dilate on one or both eyes being shaded, and also on stimulation of a sensory nerve (*sensory reflex*). Atropine and homatropine produce a dilated pupil (*mydriasis*) inactive to all the reflexes; cocain causes mydriasis, but the pupil still acts to the contraction reflexes; eserine and pilocarpine produce a contracted pupil (*miosis*) always dilating slightly on shading or on relaxation of accommodation. The pupil is influenced by the blood supply, and if there is congestion of the iris it is contracted (*congestion-miosis*).

(2) *Examination with the ophthalmoscope.*—The ophthalmoscope in its simplest form consists of a silvered glass concave mirror of about twenty centimetres focal length, with a central aperture (*sight hole*) of three millimetres diameter, fitted on a suitable handle. If required for estimating refraction, lenses are arranged to pass behind the sight hole. The examinations are made much easier by dilatation of the patient's pupil; for this purpose drops of homatropine (2 gr. to f℥j.) or of homatropine (2 gr. to f℥j.) and cocain (2 p.c.) should be placed in the eye a quarter of an hour before examination. The methods of using the ophthalmoscope may be divided into (*a*) the *direct* and (*b*) the *indirect*.

(*a*) The *direct method* may be employed in two ways, at a distance and close to the patient's eye. (1) *To use the direct method at a distance*, the patient should be sitting with the light at first just above and behind his head, the observer being about an arm's length away. Throw the reflection of the light from the ophthalmoscope-mirror through the pupil, and observe through the sight hole the pupillary area as a red colour (*red reflex*). On now slowly rotating the mirror horizontally and vertically a shadow is seen crossing the pupillary area if the refraction is abnormal (ametropic), and this shadow moves in the same direction as the mirror in myopia, and in the opposite direction in hypermetropia and in myopia of less than one dioptre (*retinoscopy*). Approaching closer to the patient

examine the media, and observe if any objects other than retinal vessels and the optic disk are seen. If so, on telling the patient to move his eye in different directions, these objects, which are usually of a dark colour, will float about if they are in the vitreous. (2) *Direct method close to the patient's eye.*—The lamp should next be moved on a level with the patient's head and on the same side as the eye under examination. On now bringing the ophthalmoscope to about two inches from the patient's cornea, and at the same time relaxing your own accommodation and telling him to look into the far distance and to move his eye about as you direct, inspect the details of the fundus. If the patient or the observer has an error of refraction it is necessary to correct it by a suitable lens behind the sight hole. Now place a lens of nine dioptres behind the sight hole to investigate the vitreous and the posterior part of the lens, and one of twenty dioptres to see the cornea, anterior chamber, iris and anterior part of the lens.

(*b*) The *indirect* method is perhaps easier to a beginner and gives an extensive and rapid view of the fundus, but is not so accurate as to minute details. The light being placed a little above and behind the patient's head, at a distance of eighteen inches look through the sight hole, your right eye at the patient's right eye, and *vice versâ*. Tell the patient to look into the far distance (to relax his accommodation) in the same direction as the fingers holding the ophthalmoscope if the disk is to be examined, or at the sight hole if the yellow spot region is to be investigated. After obtaining the red reflex, hold a lens of three inches focal length between you and the patient and at three inches from the patient's eye ; an inverted view of the fundus will be thus obtained.

The following are the chief details to be observed in the normal fundus. The *optic disk* is greyish-pink, lighter than the rest of the fundus, and nearly circular in shape ; its centre appears sometimes stippled (*lamina cribrosa*), and frequently depressed (*physiological cup*) with the retinal vessels dipping into it. The periphery of the disk is usually lighter in colour (*scleral ring*) and often bordered in part by pigment. Occasionally an opaque white striated patch, radiating from the edge of the disk, is seen with its margin gradually thinning out (*opaque nerve fibres*). The rest of the fundus is bright red, with the retinal vessels on it ; sometimes the choroidal vessels may be seen plainly as a network, and of a lighter colour than the retinal vessels. At the *yellow spot* the choroidal red is generally deeper in colour and there are no visible blood-vessels. The *retinal arteries* are as a rule smaller and lighter in colour than the veins ; both usually divide on or near the disk into superior and inferior temporal and nasal branches. The retinal veins can often be seen to pulsate even in health, and by pressing on the eyeball with the finger the arteries can be observed to pulsate.

(3) *Acuteness of vision.*—Snellen's test-types are those usually

employed for testing vision, and the letters are constructed so as to be seen under the standard visual angle (five minutes). *To test for distant vision*, place the patient at six metres from the *distant* type, and if his vision be normal, he ought to read the smallest letters, numbered six on the types. His vision is then called $\frac{6}{6}$, or 1. If he only reads the top letter it is $\frac{6}{60}$ or $\frac{1}{10}$, and so on in proportion. If the patient is under forty-five give him the *reading types* arranged on the same plan, and find out the smallest he can read at the shortest distance, thus finding his near point and accommodation. If he is too blind to see either type hold your fingers before his eye, and measure the greatest distance at which he can count them. If he is unable to see the fingers, shade his eye, and throwing light into it, see if he has perception of light. If a patient has only perception of light, the observer should, by means of the ophthalmoscope-mirror in a dark room, throw the light on the different parts of his fundus to see if all are equally light percipient (*projection*).

The *fields of vision* may now be mapped out roughly by the fingers, or by the perimeter for white and colours. Any spots of the field in which the object used is not seen are called *scotomata*. The *colour vision* is usually investigated by coloured wools.

Intra-ocular tension may be estimated by the fingers, or by instruments called tonometers; the former is the usual way, and is effected by directing the patient to look down on the ground, and then palpating the eyeball through the upper lid with both index fingers, as if trying to detect fluctuation. Certain degrees of tension have been recognised, the firm, tense, semifluctuating feeling of the normal eye being taken as the mean (*T.n*); these degrees are denoted according to the amount of increased tension + 1, + 2, + 3, or of diminished tension − 1, − 2, − 3.

I. *Diseases of the eyelids and lachrymal apparatus.*

Ciliary blepharitis (*Tinea tarsi*) is the most common inflammatory affection of the lids; it is usually chronic and occurs especially in ill-fed, dirty, hypermetropic, or strumous children. The *symptoms* are redness of the ciliary border of the lids, and either an eczematous condition of the border, or more commonly inflammation and vesication of the hair-follicles with stunted and misplaced eyelashes, followed in bad cases by scarring of the edge of the lid, and slight eversion. The best *treatment* is an alkaline lotion, as sodium bicarbonate gr. x. ad f℥j., and zinc or a weak mercurial ointment applied along the edges of the lids night and morning; in severe cases removal of the lashes and painting the borders of the lids with silver nitrate solution is advisable.

The eyelashes may be the seat of the pediculus pubis, giving rise to a condition which may simulate ciliary blepharitis if there has been much irritation.

Meibomian cyst (*Chalazion*) is the most usual form of tarsal tumour, and is due to chronic inflammation of the fundus of a Meibomian gland. It occurs as a small, hard, painless swelling, with the skin of the lid freely moveable over it. On the conjunctival surface of the lid there is usually a bluish-grey discoloured spot, due to thinning of the tissues. A crucial incision should be made through this spot, and the semi-fluid contents evacuated by pressure or by a small spoon. These cysts have no distinct wall, are generally found in young adults, and are very prone to suppurate.

Stye (*Hordeolum*) is a localised inflammation of the cellular tissue near the edge of the lid usually about an eyelash, but sometimes in connection with the duct of a Meibomian gland. It gives rise to throbbing pain, accompanied by redness, swelling and œdema of the lid and conjunctiva; it is usually succeeded by other styes, and is due to some derangement of the general health or error of refraction. It quickly disappears on evacuating the pus when present, or on pulling out the faulty lash.

Foreign body beneath the upper lid is frequently met with and gives rise to sharp pain, excessive lachrymation and photophobia. The *treatment* is to evert the upper lid and then remove the source of irritation.

Symblepharon, or adherence of the palpebral conjunctiva to the ocular conjunctiva or cornea, may occur owing to inflammation following burns, wounds, and ulcerations.

Inversion of the eyelid (*Entropion*) is produced by some affection of the conjunctiva or tarsus, or by spasm of the palpebral portion of the orbicularis muscle. The most frequent result of entropion is *trichiasis* (turning in of the lashes) giving rise to pannus, ulceration of the cornea, etc.

Eversion of the eyelid (*Ectropion*) is due to atrophy of the palpebral portion of the orbicularis muscle, to swelling of the conjunctiva, or to cicatricial contraction. Numerous operations have been planned for ectropion and entropion and the consequent faulty position of the lashes.

The **lachrymal apparatus** consists of the lachrymal gland and its ducts situated at the upper and external angle of the orbit, and the drainage system, which includes the puncta, canaliculi, lachrymal sac and nasal duct. The *lachrymal gland* may be the seat of acute or chronic inflammation, and may also be affected by hypertrophy or malignant disease. The chief lachrymal troubles, however, are associated with the drainage system, and the most marked symptom is that of watery eye (*epiphora*). The *puncta* may be everted or inverted by changes in the lid, or contracted from inflammation. The *canaliculi* may be narrowed by inflammatory changes or cicatrisation after injury, or obstructed by cilia and concretions. The entrance of the canaliculi into the sac is a very usual place for

stenosis. The *lachrymal sac* may be affected by inflammation spreading from the conjunctival or nasal mucous membrane. This may be accompanied by stricture of the nasal duct, and sometimes gives rise to a collection of mucus in the sac (*mucocele*), which presents as a fluctuating swelling near the inner canthus. On pressing over the swelling the fluid can usually be forced out through the puncta. A *lachrymal abscess* often follows a mucocele; the symptoms are then tense swelling and redness of the integument in the neighbourhood of the lachrymal sac. The *treatment* for stenosis of the puncta or canaliculi is to employ probes or electrolysis, and if these methods fail, to slit up the lower canaliculus by a Weber's knife, removing a piece of the conjunctiva from the inner side of the incision with scissors. For stenosis of the nasal duct probes should be passed to dilate it, and in many cases the use of styles for some time is advisable. In acute inflammation of the sac an incision should be made through the skin into the swelling, or the lower canaliculus should be slit up, and the pus, if found, evacuated that way; the sac should afterwards be syringed with antiseptic or astringent solutions.

II. *Diseases of the conjunctiva.*

Conjunctivitis (*Ophthalmia*), or inflammation of the conjunctiva, is characterised by a feeling of grittiness, heat, and heaviness of the lids, which tend to stick together, especially during sleep. This is accompanied by injection of and small hæmorrhages from the posterior conjunctival vessels producing a scarlet or brick-red congestion, and generally discharge from the eye.

1. **Catarrhal** (*muco-purulent*) **conjunctivitis** may be acute or chronic; it presents the usual symptoms of conjunctivitis (see above), and is accompanied by more or less muco-purulent discharge. It may occur in epidemics, and, if there is much discharge, is contagious. There is often marked enlargement of the conjunctival follicles, especially of the lower lid (*follicular conjunctivitis*). Occasionally the discharge is more plastic in nature, adhering to the lids. It is best treated by slight astringents (sulphate of zinc, gr. ii. ad f℥j.), or antiseptic lotions, as boracic acid (gr. x. ad f℥j), and by ointments placed along the conjunctival edges of the lids to prevent their sticking together. In chronic cases the refraction should be tested, as refraction-errors, especially hypermetropia or astigmatism, may produce or aggravate this condition.

2. **Purulent conjunctivitis** is an acute affection characterised by the severity and rapidity of its onset. It is microbic in origin, and the specific organism is nearly always the gonococcus. It may be conveniently divided for clinical purposes into two classes:—

(*a*) *Adult Purulent Conjunctivitis* (*Gonorrhœal Ophthalmia*), the more serious affection, is due to actual contagion with the virus, and

usually at first affects only one eye. The period of incubation may be a few hours. The lids at first are red and œdematous; the conjunctiva is swollen and infiltrated with serum (*chemosis*), and the discharge is serous in nature. This stage is soon followed by a very copious discharge of thick pus, the lids become much swollen and can with difficulty be opened, the ocular conjunctiva is greatly congested and chemosed. The great danger, if the condition is not soon relieved by energetic treatment, is infiltration of the cornea, giving rise to a perforating corneal ulcer and subsequent loss of the eye or great impairment of vision.

(*b*) *Infantile Purulent Conjunctivitis* (*Ophthalmia neonatorum*) occurs in newborn children generally on the third day after birth. It affects as a rule both eyes, and is due to inoculation from the vaginal discharges of the mother; to avoid this risk every child's eyes should be washed immediately after birth and an antiseptic solution (silver nitrate, gr. ii. ad f℥j.) dropped in. The symptoms are similar but not so severe as in the adult form, and the cornea is not so likely to become involved. *The chief complications* are corneal ulcers, leukoma adherens, anterior polar cataract, and panophthalmitis followed by shrinking of the globe.

The *treatment* must be directed chiefly to washing away the discharge as soon as it is secreted. For this purpose the eye should be thoroughly syringed or washed with a lotion of nitrate of silver (gr. ii. ad f℥j.), or of corrosive sublimate (1 to 6,000) every hour during the day, and as frequently as possible at night, care being taken to allow sufficient sleep. The lid should be everted once a day if possible and painted with silver nitrate solution (gr. x. to ℥j.), and, if practicable, ice-pads applied to the lids. This treatment should be continued as long as the discharge continues purulent. Ulceration of the cornea should be treated energetically by the actual cautery or solid nitrate of silver. If only one eye is affected, the rule in the adult, the opposite eye should be covered if possible by a watch-glass shade to prevent inoculation.

3. **Membranous conjunctivitis** is an acute affection characterised by the presence on the palpebral conjunctiva of a greyish-white membrane. It is usually associated with the *bacillus diphtheriæ*. Severe cases are marked by great pain and excessive brawniness and stiffness of the lids owing to the plastic infiltration of the mucous and submucous tissues. The membrane lasts from six to ten days, and may then be followed by muco-purulent conjunctivitis. *Treatment.*—Antiseptic lotions, warm fomentations, quinine drops, and in diphtheria cases subcutaneous injections of antitoxin.

4. **Granular conjunctivitis** (*Trachoma*) derives its name from the presence on the palpebral conjunctiva, especially near the fornix of the upper lid, of greyish raised bodies about the size of a pin's head. It may be acute or chronic, and occurs at all ages except in very young children. It is especially common in those subjected to

bad hygienic surroundings; hence its frequency in insanitary schools, marshy districts, and overcrowded camps. *The acute* form is rare in England and is accompanied usually by a muco-purulent discharge which generally absorbs the granulations and so cures the disease. In the *chronic form* the *symptoms* are a heavy look of the lids, irritable eyes, and at times a muco-purulent discharge. The muco-purulent discharge depends more upon the condition of the conjunctiva than on the presence of the granulations. The disease is probably only contagious during the continuance of the discharge. The granulations often affect the submucous tissue, giving rise to scarring. *Pathology.*—There are two views as to the nature of the granules: 1. That they are due to hypertrophy of the lymph-follicles of the conjunctiva; and, 2, that they are new growths. It may be *complicated* by superficial keratitis, pannus, ulcers of the cornea, ectropion, trichiasis, etc. *Treatment.*—In the acute form antiseptic lotions should be employed. In the chronic form, with muco-purulent discharge, paint the inside of the lids two or three times a week with silver nitrate solution (gr. x. to ʒj.), and order an astringent lotion, as zinc sulphate (gr. ii. to ʒj.), to be dropped into the eye two or three times a day. If there be no discharge, touch the granulations lightly two or three times a week with a crystal of copper sulphate. During the discharge stage the patient should be isolated.

5. **Phlyctenular conjunctivitis** is met with very frequently in children, and is characterised by the presence on the ocular conjunctiva, as a rule near the cornea border, or on the anterior surface of the cornea of one or more small nodular swellings accompanied by a limited vascular zone. Photophobia and lid-spasm are often present. The *treatment* is chiefly dietetic with the local application of yellow mercuric oxide ointment (gr. iv. ad ʒj.).

Pinguecula is a yellowish elevation, not containing fat, of thickened conjunctiva and subconjunctival tissue near the inner or outer edge of the cornea. It is present in most people over forty years of age.

Pterygium is a triangular thickened piece of the ocular conjunctiva, with its apex at the margin of or on the cornea. It is especially found in sailors and people who have lived in the tropics. If it invades the cornea to any great extent it may be dissected off and the apex stitched back on the conjunctiva.

Wounds of the conjunctiva heal well, and if extensive ought to be stitched up.

III. *Diseases of the cornea and sclerotic.*

Keratitis, or inflammation of the cornea, is characterised, as a rule, by pain, photophobia, lachrymation, impairment of vision, pink circumcorneal vascular zone, and want of the natural transparency

of the cornea. It may be conveniently divided by its position into 1, superficial; 2, instertitial; and 3, posterior or punctate.

1. **Superficial keratitis** may be due to phlyctenules, granular conjunctivitis, or may result from changes in the lids as entropion, ectropion, or trichiasis. The cornea becomes opalescent, rough and pitted; there is generally a deposition of newly-formed vascular tissue (*pannus*), the vessels of which derived from the anterior conjunctival resemble the branches of trees. The *treatment* consists in the removal of any irritating cause, and in the application of sedative lotions and mercurial ointments. In obstinate cases of pannus the operation of *peritomy* (removal of a ring of conjunctiva round the corneal periphery so as to cut off the superficial blood supply to the cornea) may be performed.

Corneal ulcer is a loss of substance attended by inflammation of the corneal tissue. It may result from injury, a phlyctenule, acute conjunctivitis or general constitutional disturbance. If not due to traumatism, it commences as a slight infiltration of the cornea, producing a limited dulness and opalescence, and this area becomes slightly raised and of a grey colour. On the superficial corneal layers giving way, the ulcer is formed, and the symptoms are those mentioned above under *Keratitis*. The ulcer may spread laterally or in depth, and when healing takes place the infiltrated area diminishes and the edges lose their ragged contour and become smooth. The depression of the ulcer is filled up by new connective tissue, blood-vessels pass to it, and the epithelium grows over from its edges. The site of the ulcer always remains less transparent, and, if the colour be grey, it is known as a *nebula*, or if white, as a *leukoma*. Fluorescine stains an active ulcer green, and is a useful aid in diagnosis. The *treatment* for an acute ulcer is by atropine drops, unless it be deep and peripheral, when eserine or pilocarpine drops are to be preferred. When chronic, an ointment of yellow mercuric oxide (gr. ij.—viii. to vaseline ʒj.) should be placed in the eye once or twice a day, and massage employed through the surface of the closed lid.

A variety called the *infective ulcer* tends to spread rapidly at its edges and also in depth; it is often accompanied by *hypopyon* (pus in the anterior chamber) and then is generally microbic in origin. The best *treatment* is the actual cautery or solid nitrate of silver applied to the edges and base of the ulcer; the evacuation of the pus in an adult by tapping the anterior chamber from below; and the local application of eserine or atropine.

2. **Insterstitial keratitis** is usually associated with congenital syphilis, sometimes with struma, and occasionally with acquired syphilis. The whole cornea undergoes a subacute or chronic inflammation; it at first looks steamy and then patchy, and like ground glass; the patches become vascular (*salmon patches*), but there is no tendency to superficial ulceration or suppuration. After some

months the eye begins to clear up under treatment even in very bad and apparently hopeless cases. Though as a rule only one eye is attacked first, the other after a few weeks or months generally becomes affected. The usual age is between five and sixteen. The attendant *complications* are iritis, secondary glaucoma, uveitis, and in very severe cases shrinking of the eyeball. After an attack there are to be found nebulæ in the cornea and always the remains, at the corneal periphery, of the vessels of inflammation. The *treatment* is the administration of small doses of mercury over a long period of time, or iron tonics, and locally atropine and yellow oxide of mercury ointment.

3. **Keratitis punctata,** though not strictly a keratitis, is a useful term for describing a condition associated with disease of the uveal tract (p. 693). It is characterised by the presence of dots of different sizes on the epithelium of Descemet's membrane. These are generally arranged in the lower half of the cornea in the shape of a conical bullet with the apex upwards. The dots may be proliferations of the posterior corneal epithelial cells, or granules deposited on the epithelium lining Descemet's membrane.

Conical cornea (*keratoconus*) is a bulging of the central portion of the cornea. It generally occurs in females, and is due to defective nutrition of the corneal tissue. It may follow an ulcer, especially if central. The vision may be improved by concave or stenopaic glasses. Operative procedures, as iridectomy, trephining the cornea, or paracentesis, sometimes do good.

Foreign bodies on the cornea ought to be removed as soon as possible. Anæsthesia of the cornea should first be obtained by dropping 4 per cent. cocain solution twice in the eye at intervals of five minutes. The patient being seated in a chair facing the light, the operator stands behind the patient, and with the fingers of the left hand separates the lids, at the same time pressing on the eyeball to steady it. Then with a spud or needle held in the right hand the foreign body should be lifted off or picked out of the corneal tissue.

Scleritis (*episcleritis*) or inflammation of the scleral tissue, is accompanied by a circumscribed reddish-purple patch of vascular congestion near the corneal margin, generally on the outer side, or by deep general congestion. It may last for some months, and often relapses; the pain and tenderness vary much in intensity, and in severe cases keratitis and iritis may be present. It is more common in women than men, and affects especially those of gouty, rheumatic, or tubercular diathesis, or patients with a syphilitic taint. The best modes of *treatment* are warm fomentations of opium, leeches, massage, belladonna and atropine if iritis is suspected, and general constitutional remedies.

Wounds of this region may be divided into (*a*) corneal, (*b*) scleral, and (*c*) sclero-corneal. (*a*) *Corneal wounds*, unless implicating the

lens or iris, generally heal quickly. (*b*) *Scleral wounds* more than ¼ inch behind the sclero-corneal junction, if small and unaccompanied by the presence of a foreign body in the eye, may be stitched up, or the conjunctiva stitched over them, and then treated by ice-pads to allay inflammation. (*c*) *Sclero-corneal wounds* are the most dangerous, especially if lacerated, owing to the risk of sympathetic inflammation, and demand great judgment in saving the eye; in many cases the eye ought to be excised, especially if the lens is injured.

IV. *Diseases of the uveal tract.*

The uveal tract comprises the iris, ciliary body and choroid, and though disease may be limited to one part, there is always a tendency for it to spread throughout the whole tract.

Iritis or inflammation of the iris may be acute, subacute, or chronic. The usual *symptoms* of a case of acute or subacute iritis are—pain and tenderness along the ophthalmic division of the fifth nerve, dimness of sight, lachrymation, injection of the episcleral vessels giving rise to a pink circumcorneal zone, and occasionally photophobia. The iris is dull and discoloured, *e.g.*, a blue iris becomes green, the pupil is sluggish, contracted, generally irregular owing to adhesions to the anterior capsule of the lens (*posterior synechiæ*), and acts badly or not at all to atropine. In chronic iritis there may be no symptoms except irregularity of pupil, dimness of vision, and at times pain. Iritis is especially likely to occur in patients suffering from syphilis, rheumatism, or gout; it may also have a traumatic origin, or be secondary to inflammations of the cornea, sclerotic, or the other parts of the uveal tract. The iritis associated with *syphilis* is often symmetrical, and generally accompanied by great effusion of lymph in the neighbourhood of the pupil. Iritis in *rheumatic* patients is usually very painful, and differs as a rule from the syphilitic variety in its great tendency to recur. It is especially liable to attack those of the rheumatic diathesis if suffering from prolonged gonorrhœal discharge. In *gouty* subjects there may be a very insidious form (*quiet iritis*). The *local treatment* should be first directed to obtaining dilatation of the pupil by atropine or by atropine and cocain combined, and also by belladonna fomentations. The eye should be bandaged, and if there is much congestion of the conjunctival vessels and pain, it is well to apply one or two leeches or a small blister to the temporal region about one inch from the external canthus. The *general treatment* is that applicable to the diathesis of the patient, but a mild course of mercury is by some always prescribed in acute iritis.

The chief traumatic affections of the iris are blood in the anterior chamber (*hyphæma*), mydriasis (due to paralysis of the sphincter pupillæ), tremulous iris (generally from dislocation of the lens), rupture of the ciliary border of the iris (*coredialysis*), a rent in

the pupillary border, and prolapse of the iris after a perforating wound.

Iridectomy.—This operation may be performed (*a*) to improve the sight in cases of corneal opacity, anterior polar cataract and lamellar cataract, (*b*) as a remedial measure in glaucoma, relapsing iritis, and complete posterior synechia, and (*c*) in cataract extraction.

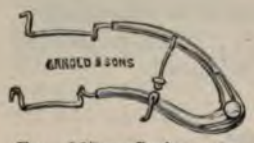


Fig. 327.—Spring eye-speculum.

Operation.—Place the patient in a recumbent posture and induce general anæsthesia, preferably by chloroform, or local anæsthesia, by means of cocain (4 per cent.). Standing behind the patient's head introduce the spring speculum (Fig. 327); fix the conjunctiva near the cornea with fixation-forceps opposite the place selected for the coloboma. Pass the keratome by pressure perpendicularly through the cornea (Fig. 328), and then lowering its handle press the blade into the anterior chamber parallel to the iris; now lower the handle still more till the point nearly touches the posterior surface of the cornea and slowly withdraw the keratome. Give the fixation-forceps to an assistant to gently depress the eye; pass through the wound the iris forceps closed, then open the forceps, seize the pupillary border of the iris, slowly draw it out, and snip it off with the scissors either parallel to the wound, or at right angles to the wound across the cornea. Carefully return the edges of the coloboma with a curette (Fig. 329), and bandage up the eye. In iridectomy for glaucoma it is the rule to make a large sclero-corneal incision (most operators preferring a Graefe's knife), and to remove the iris up to its ciliary border.

Fig. 328.—Showing speculum in eye, fixation-forceps in position, and the keratome passed into the anterior chamber in the operation of iridectomy inwards.

Cyclitis, or inflammation of the ciliary body, rarely occurs without other parts of the uveal tract being involved. The *symptoms* are circumcorneal zone of redness, pain and tenderness in the ciliary region, pain on accommodating, and punctate keratitis. Deep anterior chamber, dilated pupil, and increased tension may be present. It is best *treated by* atropine fomentations and leeches.

Fig. 329.—Curette.

Choroiditis, except as part of a more general inflammation, is rarely accompanied by external signs or severe pain. *Ophthalmo-*

scopically there may be, if recent, soft yellowish-white exudation patches either at the yellow spot or elsewhere in the fundus; these patches on clearing up leave as a rule atrophy of the choroid, showing the white sclerotic through, with the edges bordered by disturbance of pigment. The atrophic patches may be ringed, diffused, or punctate, and if due to hæmorrhage from the choroidal vessels are generally large and deeply pigmented. The retinal vessels always pass over these patches of choroiditis. Vision is as a rule, though not always, diminished. The usual causes are syphilis (acquired and congenital), myopia, tubercle and hæmorrhages. In syphilitic cases mercurial treatment should be continued for a lengthened period; the eyes should be rested by use of dark glasses.

Uveitis, or general inflammation of the uveal tract, commonly starts in the ciliary body, and is characterised by the chief symptoms of iritis, cyclitis, and choroiditis. It may be divided into (1), purulent, and (2), plastic.

(1) **Purulent uveitis** (*panophthalmitis*) has usually a traumatic origin, but may occur in pyæmia and in old blind eyes. The symptoms are extreme pain, acute congestion and œdema of the lids and conjunctiva, and after a few days, if the media are transparent enough, a yellowish reflex, due, as a rule, to suppuration in the vitreous. The usual course is for the inflammation to affect the whole interior of the eyeball, and afterwards the extrinsic muscles and Tenon's capsule. The *treatment* is by incisions into the eyeball to allow free vent to the pus or by evisceration. Meningitis has occasionally followed enucleation in these cases.

(2) **Plastic uveitis** is characterised by a great tendency to deposition of lymph, and may be divided into Acute and Chronic.

(*a*) *Acute plastic uveitis* (*Sympathetic Inflammation* or *Sympathetic Ophthalmia*) is set up in one eye by morbid changes usually the result of a wound of the other eye. The injured eye is called the "exciting," and the other the "sympathising eye." It occurs usually from six weeks to three months after injury. It is preceded as a rule by a condition known as "Sympathetic Irritation," characterised by lachrymation, photophobia, dimness of sight, oscillations of the pupil and frontal neuralgia. The *symptoms* are impaired vision, circumcorneal zone, keratitis punctata, deep anterior chamber, iritis, papillo-retinitis, and opacities in the vitreous. These symptoms are followed by thickening and vascularisation of the iris, occlusion of the pupil by lymph, shallow anterior chamber, diminished tension, shrinking of the vitreous, detachment of the retina, etc. The prognosis is very unfavourable, as only in a few cases the changes stop short of actual loss of the eye for useful vision, and it must always be remembered that the *sympathising* eye suffers as a rule more severely than the *exciting*. The nature of the disease is probably a microbic inflammation spreading from the exciting eye by the optic nerves and chiasma to

the sympathising eye. The *treatment* consists in confinement to a dark room, goggles, atropine, leeches and mercury. If the exciting eye is quite blind it should be excised, but if it has useful vision it should be saved.

(*b*) *Chronic plastic uveitis* occurs as a rule in strumous and syphilitic patients. The disease progresses like "Sympathetic Inflammation," but is more chronic; it usually affects both eyes at intervals, and may pass on to complete blindness. In young children plastic uveitis may produce a condition called "*pseudo-glioma*," which can be diagnosed as a rule from glioma by discoloration and adhesion of the iris, minus tension, etc. A less severe and more common form of chronic plastic uveitis may be called *Anterior uveitis* (*serous iritis*) from its affecting the anterior part of the uveal tract. It is characterised by keratitis punctata (p. 692), deep anterior chamber, dilatation of the pupil, increased tension, and the usual symptoms of iritis and cyclitis, accompanied frequently by a few peripheral choroidal changes, and small vitreous opacities. It is generally found in young adults, especially women, and is associated with anæmia, gout, rheumatism, and struma. The *treatment* is complete rest for the eyes, and atropine drops, with careful watching of intra-ocular tension.

The *Uveal tract* may be affected in any part by sarcoma (generally melanotic), the usual primary ocular seat of sarcoma being the choroid of the ciliary body.

V. *Diseases of the crystalline lens.*

Cataract is the name applied to an opacity, complete or partial, of the lens or capsule, and is due to structural changes. Cataracts may be divided into *hard* or *soft*, according to their consistency, and this usually depends on age, as under thirty-five they are all "soft." They are called *primary* when independent of any other ocular affection, and *secondary* when following some other disease, as glaucoma, intra-ocular tumour, etc. Though all cataracts at first are incomplete or partial, yet it is advisable to make a division into (1) complete (including those that in time tend to become complete), and (2) partial (those that do not, as a rule, tend to become complete).

(1) **Complete cataracts** are usually senile or hard, and are called, according to their seat of origin, nuclear or cortical. Nuclear cataracts are characterised by an opacity at the nucleus of the lens; they are often amber in colour and mostly hard, except sometimes in diabetes; cortical cataracts, which are the more common, begin as flakes or streaks radiating from the axis of the lens. Congenital cataract may occur as a general opacity of the lens; and it is usually binocular. A complete cataract may degenerate and its cortex become fluid (*Morgagnian Cataract*).

(2) **Partial cataracts** include (*a*) lamellar, (*b*) anterior polar, and (*c*) posterior polar.

(*a*) *Lamellar* (*zonular*) *cataract* is either congenital or forms in early life; it is generally associated with a history of infantile convulsions, and with a deficiency in the enamel of the teeth. The opacity is situated as a shell between the nucleus and cortex, which are both clear. It is usually symmetrical.

(*b*) *Anterior polar* (*pyramidal*) *cataract* is a small dense white central opacity on the anterior capsule of the lens, often due to perforation of the cornea in early life, and as a rule associated with corneal nebula.

(*c*) *Posterior polar cataract* is situated at the posterior pole of the lens. The opacity is generally in radiating spokes, and is often accompanied by disease of the vitreous or choroid.

Diagnosis.—When a cataract is complete it looks white, amber, or grey, and may be best seen by dilating the pupil, and examining by focal light. When incomplete and cortical the striæ may be seen by oblique illumination if the pupil is dilated, or by throwing light into the eye by the ophthalmoscopic mirror (preferably a plane mirror), when the striæ will appear as black lines.

The *subjective symptoms* in incipient cataract are failing vision, black fixed spots or lines before the eyes, ability to see better in the dusk owing to dilatation of the pupil, myopia, and sometimes monocular diplopia or polyopia.

Treatment.—In incipient senile cataract, especially of the nuclear variety, weak atropine (gr. $\frac{1}{2}$ to gr. j. to $\overline{3}$j.) drops will often temporarily improve the sight, and may be ordered with caution.

The operations for removal of the lens are of two kinds, namely (*a*) *extraction*, and (*b*) *discission*; extraction is always preferable in hard cataracts, and sometimes in soft, especially in adults. It is of course necessary before proceeding to operation that the condition of the eye be satisfactory as far as the lids, conjunctiva and lachrymal apparatus are concerned, and that there is good perception and projection of light. The tests for the perception and projection of light should never be omitted, since, if the eye is blind or the fundus is seriously diseased, the removal of the cataract would be useless and unjustifiable. In senile cataract it is usual to wait till the vision of one eye is reduced to perception of large objects, and the vision of the other is beginning to be impaired. The general health of the patient must also be investigated, as senile cataract may be associated with gout, glycosuria, albuminuria, and arterial disease.

(*a*) The *extraction operations* are numerous, but the only one described here will be the 3 millimetre flap operation, which may be performed with or without iridectomy.

Operation.—The first steps are as in operation for iridectomy (see p. 694). After the introduction of the spring speculum, fix

from retinal and choroidal hæmorrhages. The opacities m
different shapes and sizes, and in syphilis are very mi
dust-like. The patient complains of seeing black specks
before the eyes, and the vision is often much reduced.
degeneration the vitreous may be fluid, and contain ch
crystals.

Suppuration of the vitreous (*suppurative hyalitis*)
injury or to extension of a purulent uveitis, and is sometim
pseudo-glioma, from the yellowish fundus reflex. *Foreign*
steel, glass, etc., may be found in the vitreous, and, if stee
can be removed by the electro-magnet introduced thro
original wound when scleral, or through an incision in the

VII. *Glaucoma.*

Glaucoma is a condition of the eye dependent on exces
intra-ocular pressure. The chief *symptoms* are increase
ocular tension (elicited by palpating the eyeball with bo
fingers through the closed lids); ocular pain and ten
enlargement of the perforating vessels; impaired sensibility
ness, and pitted appearance of the cornea; shallow anterior c
dilatation of the pupil; greenish fundus reflex; pulsatio
retinal arteries, and engorgement of the retinal veins; und
and cupping of the optic disk; diminished acuity of vi
light sense; and limitation of field of vision chiefly on n
These symptoms are generally preceded or accompanied b
vision (everything seen in a grey or yellow fog), coloured c
rings (rainbows) round lights (red outside and bluish-green
neuralgia along the branches of the fifth nerve, and rapidly i
presbyopia necessitating frequent changes of glasses.

Varieties.—Glaucoma may be divided into (1) acute, (2) s
and (3) chronic.

1. *Acute glaucoma* is characterised by the severity and su
of its onset, and from the vomiting, megrim, etc., accompa
has often been mistaken for a bilious attack. The steamine
cornea prevents as a rule any view being obtained of the
although the pupil is widely dilated. The optic disk whe
is found in first attacks not to be cupped, but there is
pulsation of the retinal arteries and engorgement of th
Such an attack may subside after a few days, but is
followed by others until the eye may pass into a permanent
matous condition (*absolute glaucoma*) and vision be totally d
Absolute glaucoma is accompanied by great pain and
tension, intra-ocular hæmorrhages, opacity of the lens, u
and staphyloma of the cornea, and shrinking of the wh
Some cases of acute glaucoma are accompanied by sev
ocular hæmorrhage (*hæmorrhagic glaucoma*).

2. *Subacute glaucoma* is characterised by the symptoms of glaucoma as given above. There is generally a gradual progress, sometimes with exacerbations, and it may at any time give rise to acute glaucoma.

3. *Chronic glaucoma* may follow an acute or subacute attack, but there is an insidious and progressive form usually attacking both eyes, in which all irritative signs are absent. Without pain and often with no apparent increase of tension, there is gradual reduction of the amplitude of accommodation, and diminished corneal sensibility, together with cupping and progressive atrophy of the optic disks, generally ending in absolute blindness.

Pathology.—Glaucoma may be produced by any circumstance tending to upset the normal relation of the secretion and excretion of the intra-ocular fluids. These fluids, secreted by the ciliary processes, pass chiefly out at the angle between the iris and the cornea (*iridic or filtration angle*). This increased tension may be produced by hypersecretion of the ciliary processes, obstruction at the filtration angle, or by serosity of the fluids. The most frequent cause is obstruction of the filtration angle due to inflammatory products, or to mechanical means as growth of the lens, or dilatation of the pupil especially by atropine. Glaucoma occurs as a rule in persons over forty years of age, is frequently hereditary, and is often associated with hypermetropia. It may be *secondary* to complete posterior synechia, perforating ulcers and wounds of the cornea, dislocation of the lens laterally and into the anterior chamber, cataract operations, intra-ocular tumours, and intra-ocular hæmorrhage.

The *treatment of acute glaucoma* is by instillation of eserine (especially if the attack is caused by atropine) or by a large iridectomy (p. 694), as much as one-fifth of the iris being removed. Several other operations, as sclerotomy, have been recommended. In *glaucoma absolutum* puncture of the sclerotic often relieves the pain. In *subacute* cases iridectomy is generally indicated, but in *chronic glaucoma* without marked tension operative procedure probably does little good.

VIII. *Diseases of the orbit.*

Subconjunctival hæmorrhage, due to a blow on the eye or to rupture of a small vessel, owing to cough, or strain, is of a bright red colour. The blood effusion is more marked anteriorly and does not pass far back. Exactly the converse as to the position of the blood applies to deep orbital hæmorrhage following fracture of the anterior fossa of the skull.

Orbital abscess and orbital cellulitis, when acute, are difficult to diagnose from each other. Though often traumatic they may be due to cold, irritation of a tooth, erysipelas or pyæmia, and sometimes originate in periostitis. They are usually characterised

by swelling of the lids, chemosis of the conjunctiva, pain on
ments of the eye and on pressing back the eyeball, limitat
the ocular movements, facial neuralgia, and proptosis; som
there is a defined, tender, fluctuating swelling. If the syn
are not soon relieved, especially in orbital cellulitis, papillit
atrophy of the optic nerve may ensue and also meningitis.
abscess may be chronic and simulate a solid tumour. The
ment consists in early evacuation of the pus, hot fomentatio
constitutional remedies.

Tumours of the orbit usually cause protrusion of t
(*proptosis*), impairment of its movements, and papillitis o
atrophy. Generally one orbit only is affected. The origin
orbital tumour may be *primary*, in the lachrymal gland,
loose orbital tissues, in the periosteum, in the eyeball or
optic nerve; or *secondary*, starting from a neighbouring
The *primary tumours* may be cystic (hydatid, dermoid);
(ivory exostosis), sarcomatous, and vascular (nævi). Amon
secondary tumours may be mentioned arterio-venous commu
in the cavernous sinus giving rise to a pulsating tumour, a
tension of the frontal sinus by retained mucus (*frontal m*
The *treatment* is mainly the same as in other parts. Ma
tumours should be freely removed with, if necessary, the eyeb
the contents of the orbit, and chloride of zinc paste in som
applied on strips of lint for a few days afterwards.

Enucleation of the eye.—Patient lying down and as
under general anæsthesia; operator standing behind the
spring speculum in lids. Seizing the conjunctiva with a
fixation forceps at outer or inner border of cornea, divide th
junctiva and subconjunctival tissue all round the corne
scissors; raise each rectus tendon in succession on a squin
(Fig. 335) and divide each one close to the globe; now se
the limbs of the speculum and the eyeball will project for
pass a pair of stout curved scissors, closed, behind the globe
the outer side, and feel for the optic nerve; then pull ba
scissors slightly, open them and divide the nerve. The
now pushed forwards by the scissors, is taken between the
and thumb, and the other attachments are divided by the sc
After the operation, firm pressure is applied by a bandage.
is but rarely any trouble from hæmorrhage. An artifici
may be given about three months after operation, if the
is healthy.

IX. *Errors of refraction and accommodation*

The light percipient portion of the eye exists at the extern
of the retina (*rods and cones*), and it is necessary for perfect
that images of external objects should be accurately focus

this layer. Rays of light passing into the eye are refracted at the anterior surfaces of the cornea, lens and vitreous, and brought to a focus at a point varying with the refraction. The human eye for the sake of simplicity may be considered as represented by a convex lens of 23 mm. focus; and the following laws regulating the passage of light through a convex lens will then be applicable to it. Rays of light passing through a convex lens (Fig. 334, L) parallel (P) to the principal axis (X X), and therefore coming from infinity, are brought to a focus at a point (Em.) (*principal focus*) varying inversely in distance to the convexity of the lens; rays coming from a point (D) closer than infinity (*divergent rays*) are refracted further back (My.) from the lens than the focal point; and rays coming from a point (C) beyond infinity (*convergent*) are focussed at H between the lens and its principal focus Em.

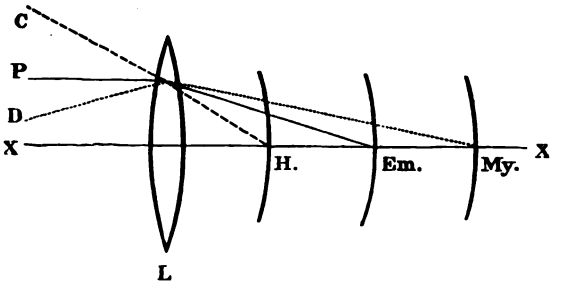


FIG. 334.—Diagram to illustrate errors of refraction. L. Convex lens. X X. Principal axis. D. Divergent ray. P. Parallel ray. C. Convergent ray. H. Em. and My. Position of retina in hypermetropic, emmetropic, and myopic eyes.

Emmetropia.—In an eye of normal refraction (*emmetropia*) with its accommodation relaxed, parallel rays (P) passing through the pupil will be focussed by the surfaces at a point (Em.) represented by the external surfaces of the rod and cone layer of the retina; divergent rays (D) will be focussed behind the retina at My.; and convergent rays (C) in front of the retina at H. In order to focus the divergent rays (D) upon the retina (Em.) it is necessary to increase the convexity of the lens and so shorten its focal length. This is done by accommodation, and a young emmetrope with normal accommodation should be able to focus on his retina all rays from parallel to divergent ones starting from a few inches in front of his cornea.

Hypermetropia is the condition in which in the eye at rest the retina (H) only receives certain convergent rays (C); parallel rays (P) and divergent rays (D) are refracted beyond the retina (H). This takes place owing to the distance between the cornea and the retina being too short, or from lessened convexity of the lens; the usual

cause is congenital shortness of the axis of the eye. Hypermetropes from this fact are obliged to accommodate for parallel rays, and still more for divergent ones. The *treatment* naturally is to increase the convexity of the lens artificially by giving a convex lens; and by so doing allowing parallel rays to be refracted on the retina, and then the ciliary muscle ought to be able to focus divergent rays on the retina. In children and young adults, to find out their hypermetropia it is often necessary to order atropine before testing the refraction, but in adults homatropine and cocain drops applied twice are enough. The *symptoms* of hypermetropia are pain and discomfort on reading, congested eyelids and conjunctivæ, spasm and fibrillar twitchings of the lids, convergent strabismus, and headache. Hypermetropia is usually congenital, often hereditary, and is frequently associated with a flat-looking face, shallow orbits, and small eyes.

Myopia is the opposite condition to hypermetropia, and in it the retina (My.) only receives certain divergent rays (D). It is due as a rule to the axis of the eye being too long, or in some cases to the ciliary muscle rendering the lens too convex (*spasm of accommodation*). The *treatment*, except in cases of spasm of accommodation, is to give concave glasses to allow parallel and other divergent rays to fall on the retina. In low degrees of myopia it is only necessary to order glasses for distance, but in high degrees it is usual to order a stronger pair for distance, and a weaker pair for reading. In apparent myopia due to spasm of the ciliary muscle it is important to order atropine to find out the true refraction. Myopes often have the head elongated in the antero-posterior diameter, a long face and large prominent eyes. Myopia is generally accompanied by a crescent at the outer side of the disc or by posterior staphyloma, and there may be secondary choroidal trouble, detachment of the retina, and vitreous opacities.

Astigmatism is the condition in which one or more of the refractive surfaces have not the same curvature in all directions. Astigmatism may be divided into—(1) *irregular*, in which there is a difference of refraction in the different parts of the same meridian due to changes in the lens and cornea; and (2) *regular*, where there is a difference in two meridians (*chief meridians*) at right angles to one another, and called those of maximum and minimum refraction. It is usually corneal (*static astigmatism*), but may be due to the ciliary muscle (*dynamic astigmatism*). Regular astigmatism may be (*a*) *simple*, where one meridian is emmetropic and the other hypermetropic or myopic, and is then called simple hypermetropic or simple myopic astigmatism; (*b*) *compound*, where the chief meridians are unequally myopic (compound myopic astigmatism) or unequally hypermetropic (compound hypermetropic astigmatism); or (*c*) *mixed*, where one chief meridian is hypermetropic and the other myopic. Persistent headache is commonly met with in

astigmatism. The *treatment* is by cylindrical glasses for simple astigmatism, and by cylindrical glasses in combination with sphericals for compound and mixed.

Presbyopia.—In the eyes of all persons from forty to forty-five years of age it is found that, owing to changes in the elasticity of the lens, the ciliary muscle begins perceptibly to lose its power of altering the convexity of the lens. The effect of this will be to prevent near objects being focussed on the retina at the usual reading distance; in order to counteract this condition and to help the ciliary muscle it is necessary to prescribe convex glasses for reading. It has been found that the glass needed is about one dioptre for every five years after forty.

X. *Strabismus and ocular paralysis.*

Strabismus (*squint*) is always present when the two eyes are not directed simultaneously towards the same object, and is usually accompanied at some time by double vision (*diplopia*). Strabismus occurs from over-action, weakness, or paralysis of one or more of the extrinsic ocular muscles. It is usually convergent or divergent, but may be upward or downward. It may be constant (*fixed*) or occasional (*periodic*), and though usually only one eye squints, yet sometimes both eyes may do so in turn (*alternating*). When the squinting eye follows its fellow normally in all its movements the squint is called *concomitant* in contra-distinction to *paralytic*. Diplopia is much more marked in paralytic than in concomitant squint. The non-squinting eye is called the *fixing* eye, and strabismus may be estimated by telling the patient to look at an object about two feet away with the fixing eye, and then taking the distance between the middle of the palpebral aperture and the middle of the cornea of the squinting eye (*primary squint*); on now making the squinting become the fixing eye the amount of deviation of the original fixing eye is taken (*secondary squint*). In *paralytic* cases the secondary squint exceeds the primary, but it is equal to or less than the primary in *concomitant* squint.

Convergent strabismus (*internal squint*) is most commonly due to hypermetropia, owing to the fact that the excessive accommodation necessitates a correspondingly great convergence; but it may occur occasionally in myopia, and also follows division or paralysis of an external rectus.

Divergent strabismus (*external squint*) is caused from insufficiency of convergence power, and weakness of the internal recti, especially in myopia; from defective vision of an eye, as in corneal nebulæ; and from division or paralysis of an internal rectus.

The *treatment* of concomitant strabismus is by atropine, eserine, spectacles, prisms, and stereoscopic exercises. The operations that may be required are either tenotomy of the muscle of the affected

side, or advancement of the muscle of the opposite side. As a
only one eye should be operated on at a time. The treatm
paralytic strabismus is by constitutional remedies and galvan
the affected muscle.

Tenotomy of the internal rectus.—Patient lying down and
cocain or general anæsthesia; operator standing in front
the right-hand side. Introduce the spring speculum, and pi
with a pair of fixation-forceps the conjunctiva and subconju
tissue at the point of junction of the lower horizontal an
vertical tangents of the cornea. Divide this fold with a
blunt-pointed scissors, making the incision only large eno
admit the points of the scissors, and then, passing the
through the incision, divide the capsule of Tenon. P
strabismus hook (Fig. 335) into the wound, directing its poin
wards, and then turn the end of the hook upwards betw
globe and the tendon, until its point is seen beneath the conju
at the upper border of the tendon. Introduce the scissors t
the wound, and open the blades on either side of the tendon b
the globe and the hook, and by one or two snips cut thro

Fig. 335.—Strabismus hook.

tendon. Remove the hook and then reintroduce it to ascer
the tendon is completely divided. The eyes should be
for about twelve hours. The method is the same for the
rectus, but it must be remembered that the tendon is
little further back.

Ocular paralyses.—*Complete Paralysis of the Third*
characterised by complete ptosis; external strabismus; in
move the eye completely up, down, or in; crossed diplopia;
mydriasis and inactivity of the pupil to all the re
paralysis of accommodation. Any one of the muscles s
the third nerve may be separately paralysed, also th
oblique (fourth nerve) and the external rectus (six
Paralysis of the external rectus gives rise to internal
inability to move the eye outwards, and homonymous di
is the most common of the ocular palsies, probably fro
course of the sixth nerve. All the external ocular mus
paralysed at the same time (*ophthalmoplegia externa*).

The intra-ocular muscles are the pupillary (*sphincter p*
the ciliary. The *pupillary* muscle may be affected by
the third or short ciliary nerves, producing medium
by paralysis of the cervical sympathetic or long c
producing partial miosis. The ciliary muscle may

(*cycloplegia*) by affections of the third or short ciliary nerves, usually in conjunction with paralysis of the pupillary muscle. It may be paralysed alone as in diphtheria. In certain diseases, especially locomotor ataxia, the pupil acts to accommodation but not to light (*Argyll-Robertson or spinal pupil*).

The *treatment* of ocular paralyses is chiefly constitutional. Many are of syphilitic origin, and require mercury or iodide of potassium; but faradisation of the affected muscle may also be employed. In mydriasis and cycloplegia the use of eserine is indicated.

Nystagmus (*involuntary oscillations of the eyeball*) is generally binocular, and the movements of the eyes are usually horizontal or rotatory. It occurs as a rule in early life, and is then due to defect of sight from corneal ulcer, etc.; sometimes in adult life in patients with diseases of the nervous system, such as disseminated sclerosis, and in coal miners, in whom it is probably due to their position at work.

DISEASES OF THE LIPS AND CHEEKS.

Herpes of the lip.—A crop of herpetic vesicles which burst in a few days leaving small scabs, are common on the lip during slight attacks of catarrh, indigestion, etc. Their occurrence in pneumonia is well known.

Cracks and fissures of the lip following exposure to cold, etc., in dyspeptics, are very common, and, if neglected, may form deep and painful fissures, prone to bleed and obstinate to heal. They may leave a permanent and disfiguring scar. A simple ointment, and if persistent, touching them with solid nitrate of silver, will generally suffice to cure them. Should the margins become indurated and resist the above treatment, the scar may be excised by a V-shaped incision and the wound united by horsehair sutures. They must not be mistaken for the fissures about the corners of the mouth so common in congenital and acquired syphilis.

Papillomata or warty growths of the lip are of interest in that they are liable as age advances to become epitheliomatous. They may sometimes grow out in the form of horns. Extirpation with the knife is the proper treatment.

Superficial ulcers on the inner surface of the lip are common accompaniments of errors in digestion, and of secondary syphilis. There are usually similar ulcers on the side of the tongue and cheeks. Nitrate of silver or chromic-acid lotions (gr. x. to ʒj.) are the best local applications.

Nævus of the lip when small may be touched with nitric acid or ethylate of sodium; and when pendulous and projecting from the free margin, ligatured. When involving the whole substance of the lip it may be treated by electrolysis, or, better, excised by means of a V-shaped incision.

Epithelioma (*squamous carcinoma*) nearly always occurs in men, and on the lower lip; and although it may affect non-smokers, it generally appears to be due to the irritation and heat of a short clay pipe. Occasionally it has been met with in the upper lip, and in women, but the latter have usually been smokers. It begins as a crack, indurated tubercle, or warty growth, and may either spread superficially along the free margin of the lip, or extend deeply into its substance, forming an indurated ulcer covered by a dry crust, beneath which are smooth granulations. Sooner or later it involves the whole lip and adjoining parts, becomes adherent to the jaw, and invades the bone. The lymphatic glands in the neck become involved and may attain a large size, even whilst the primary growth in the lip is quite insignificant; dissemination through internal organs is rare. If removed early an epithelioma of the lip may not recur till after a long period of immunity, or perhaps not at all. It seldom returns in the scar, but in the lymphatic glands, the patient dying from exhaustion and septic poisoning induced by ulcerating and bleeding masses in the neck, and more rarely from implication of the trachea and œsophagus. The affection is very apt to be mistaken for *hard chancre*, and the latter has ere now been cut away under the impression that it was an epithelioma. The following points should serve to distinguish them: 1. Epithelioma generally occurs in the old, and in men, and on the lower lip; chancre in the young, in women, and on the upper lip. 2. The epitheliomatous ulcer has hard, sinuous, and everted edges, and an indurated and warty base; the chancrous is raised, excoriated, smoother, and the induration is more circumscribed. 3. In the malignant affection, the glands, as a rule, are not affected till late in the disease—perhaps six months; in the syphilitic very early, within six weeks. Moreover, in chancre secondary symptoms will be present or soon appear, and the disease readily yields to antisyphilitic remedies. *Treatment.*—Free and early excision is imperative. The growth should be included in a V-shaped incision, the wound being afterwards united by hare-lip pins or fishing-gut sutures. Although not perceptibly enlarged, the submental glands should be extirpated at the same time by extending two curved incisions from the angle of the V to either side. When the bone is involved, a portion of the jaw may be removed if the whole disease can be got away. If the glands are extensively enlarged, forming a huge and perhaps ulcerating mass beneath the jaw and in the side of the neck, the disease had better be left alone.

Hare-lip is a congenital malformation in which the upper lip is vertically cleft on one or both sides of the median line, and very rarely in the median line itself. It is so named from its fancied resemblance to the lip of the hare, in which animal, however, the cleft is always median. It is said by Kölliker to be produced by the failure of union of the fronto-nasal process, which forms the

tissue. It may also be the seat of lymphangiectasis, projecting on the surface or of lymph cysts in the int occur or not with macroglossia. The enlarged lip n seat of an angioma, or of a capillary or venous næ shaped piece should be excised, including the portion nævus or lymphangiectasis.

Chancre of the lip is most frequently met with life and in women; it sometimes occurs in infants direct inoculation by mucous tubercles on the lips of or may be conveyed by cups, spoons, pipes, towels, as a painless circumscribed, somewhat indurated patc smooth surface and regular outline, and is attende ment and induration of the submaxillary glands, and eruptions and other signs of secondary syphilis. T speedily disappears under a mercurial course. For epithelioma, see *Epithelioma*.

Carbuncle of the lip is a most dangerous disea likely to lead to infective phlebitis of the facial ve spread thence through the ophthalmic vein to the other cranial sinuses, and terminate in infective n general blood-poisoning. It may be distinguished f pustule, which it may somewhat resemble, by the anthrax bacillus. Free incisions should be mad scraped away, and antiseptics applied; or if this i carbolic acid lotion (1 in 20) may be injected by inflammatory zone, and the strength supported by flu and stimulants. Streptococceal antitoxin may be tri

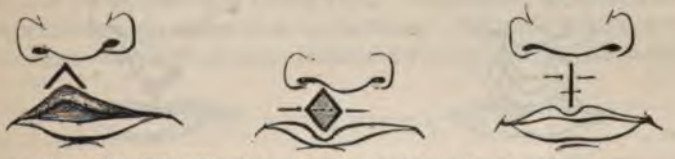
Adenomata, or labial glandular tumours (P ally occur in the lip as small, smooth, elastic gro under the mucous membrane. They are sometimes of

well freeing the lip from the gums at the apex of the cleft so as to avoid tension ; by using a sharp knife so as to insure clean incisions ; by taking care to completely pare the margins of the cleft, and to remove sufficient tissue to secure broad, raw surfaces ; by passing the hare-lip pins on the same level, and deeply enough to bring the whole of the raw surfaces into contact ; and by making the cuts in paring the edges concave towards the middle line of the cleft, so as to lengthen the line of union and allow for retraction.

Fig. 336.—Smith's clamp for controlling hæmorrhage during operation for hare-lip.

Operation for single hare-lip.—Having placed a Smith's clamp (Fig. 336) on the lip on either side of the cleft to control hæmorrhage, pare the edges of the cleft with a sharp narrow-bladed scalpel, taking care to remove the whole of the rounded portion of the prolabium on each side of the base of the cleft ; and having freed the lip from the gums at the apex of the cleft, bring the raw surfaces together by hare-lip pins, passing the lower one first to ensure the free edge of the lip and prolabium being in line. The

Fig. 337. Fig. 338. Fig. 339.



Figs. 337, 338, 339.—Operation for single hare-lip when the fissure does not extend into the nostril.

lower pin should be entered a quarter of an inch from the margin of the cleft, and made to transfix the coronary artery ; but it should not penetrate the mucous membrane, as, if this be done, the mucous membrane will double in and prevent union. A second pin will generally be necessary, and should be passed in the same way, and a silk suture twisted round each. The sharp ends of the pins should be nipped off with pliers, a small piece of gauze placed beneath them to prevent injury to the cheek, and several sutures of horsehair passed superficially to keep the edges of the wound in accurate

apposition. The parts should then be dried, and covered with iodoformised collodion, and a dumb-bell-shaped piece of strapping applied across from cheek to cheek to prevent traction. The pins should be removed at the end of twenty-four to thirty-six hours, as otherwise they will leave scars. The twisted suture should be left on till firm union has occurred, and the strapping re-applied. Where the fissure does not extend through the whole lip, an inverted V-shaped incision may be made, with its angle just above the apex of the

Fig. 340.

Fig. 341.

Figs. 340, 341.—Operation for single hare-lip when the sides of the fissure are unequal.

cleft (Fig. 337), each arm stopping short of the prolabium; the tissues included in the arms of the V should now be drawn down, and a diamond-shaped wound thus formed (Fig. 338). On bringing the raw surfaces together, a projection in place of the fissure will exist on the free border of the lip (Fig. 339); but this will disappear in time, leaving the lip nearly natural. When there is much irregularity between the two portions of the lip (Fig. 340), the incision on the shallower side should stop short of the prolabium, so as to

Fig. 342.

Fig. 343.

Figs. 342, 343.—Operation for double hare-lip.

allow the flap thus formed to remain attached at its base. On the deeper side the incision should slope off at an angle through the prolabium, completely removing the tissue. The flap left on the shallower side should be now turned down and united to the sloped-off portion on the deeper side, and the vertical portions of the incision brought together as usual. Thus, what was the free edge of the cleft on the shallower side now becomes the free edge of the lip (Fig. 341).

Operation for double hare-lip.—When the intermaxillary process projects, it should not, as a rule, be removed, but a week or ten days previous to the operation for uniting the lip be partially

detached with the cutting pliers, having one blade blunted by being wrapped in lint, and then be forced back into place and there secured by a plug of gauze in the wound, a pad over it, and a dumb-bell-shaped piece of strapping fixed to the cheeks. In some cases the forcing into place of the intermaxilla will be facilitated by excising a wedge-shaped portion of the nasal septum to which this bone is attached. There are many ways of uniting the lip. The simplest, perhaps (Figs. 342 and 343), consists in paring completely the central portion, and then making two flaps from the lateral portions, bringing them down and uniting them to each other below the central portion, and also to it, so that they may fill up the gap left by the deficient length of the central portion.

Rodent ulcer (see p. 157, Fig. 56) most often occurs on the face, especially near the inner canthus of the eyelid and the sides of the nose, first as a nodule, then as a small ulcer covered with a scab. The skin around is healthy. Although attempts at cicatrisation are sometimes seen, the cicatrix readily breaks down, and the ulcer, which never quite heals, slowly extends, destroying muscle, cartilage, and bone, till at the end, perhaps, of twenty or thirty years it has destroyed a great part of the bones of the face, one or both of the eyes, and the cartilages and bones of the nose, leaving a horrible and unsightly chasm. *Treatment.*—The growth whilst quite small or the ulcer should be freely excised. If done early the prognosis is good, as it is only when some of the growth is left that a recurrence need be feared. Even in later stages free removal with the knife will stop its further progress. The gap may subsequently be closed by a plastic operation or by epidermal grafts. Recently the treatment by *x* rays has been so successful in causing the ulcer to heal, and that apparently in a permanent manner, that it should be tried in all cases before resorting to the knife. In yielding to treatment by *x* rays rodent ulcer differs from epithelioma. The latter is made worse, it becomes vascular, and grows faster and requires immediate excision.

DISEASES OF THE PAROTID GLAND.

Acute simple parotitis, or mumps, is an acute infectious disease attended with sharp febrile disturbance, and with a local inflammation of the parotid gland. There is generally much pain and swelling, but neither redness nor tendency to suppuration. On the subsidence of the inflammation in the one gland, the opposite, if not already affected, generally becomes inflamed, or more rarely the submaxillary or sublingual gland is affected or the testicle, ovary, or mamma is attacked—a condition spoken of as metastasis. Confinement to the house, a gentle laxative, and a belladonna or opiate liniment or poppy fomentations to soothe the pain, is all that is usually required.

Acute septic parotitis is the result of septic operations, and it

may follow wounds and operations, especially those involving the abdominal cavity. If the original source of the septic mischief yields toxins only, the parotitis may subside, but if there is septicæmia, diffuse suppuration with multilocular abscesses ensues, which, especially if bilateral, may end fatally.

Chronic parotitis causes an indolent enlargement of the whole gland. It may result from obstruction of the duct by a calculus, and the gland swells up, especially during mastication. It is also connected with xerostomia, or dry mouth (p. 733), the obstruction to the duct then being due to inspissated secretion. A chronic interstitial inflammation is set up, and a cyst or fistula may form. *Treatment.*—A calculus, if present, should be removed and a communication with the mouth formed as in the case of parotid fistula (p. 499). A cyst may be excised. When the enlargement is connected with xerostomia, massage may relieve.

Parotid abscess.—A circumscribed unilocular abscess may arise from suppuration in one of the lymphadenoid masses within the capsule of the parotid, as the result of cutaneous irritation, tuberculous disease, or may form around a calculus. *Treatment.*—The incision should be made horizontally to avoid dividing the facial nerve, and should not extend as far back as the temporal artery.

Diffuse suppuration follows acute septic parotitis (see above) and is pyæmic in origin. A brawny mass forms on one or both sides. *Treatment.*—An incision should be made, which must extend behind the line of the jaw, as much of the inflammatory material as possible scraped away, and the cavity swabbed out with a strong antiseptic and plugged with gauze or fomented. This must be done quite early or the patient will die of septicæmia.

Parotid tumours.—Both innocent and malignant tumours occur in the parotid gland. The *innocent* tumours generally affect one lobe or the superficial part of the gland. They are encapsuled, grow slowly, press aside the rest of the parotid, which becomes atrophied but is otherwise unaltered, shell out freely, and if removed do not recur. If left alone they may attain a large size in the course of years. Many forms of innocent parotid tumours have been described as fibrous, adenomatous, myxomatous, and cartilaginous. The latter tumour so commonly met with in this situation has a mixed structure, and was formerly spoken of as consisting of cartilage interspersed with fibrous and myxomatous tissue and with atrophied glandular elements. The more likely view, however, is that which classes it as an endothelioma derived from the endothelium of lymphatics and lymph-spaces (Fig. 45). The growth of the endothelial cells fills the lymphatic vessels and spaces with a hyaline substance, which thus has a cartilaginous arrangement, and has been called cartilage, but bears only a superficial resemblance to that substance. Some of the cells may develop into fibrous tissue, whilst others undergo mucoid degeneration. The endothelium of the capillaries may develop and form

circulation was the cause of the epilepsy. Epilepsy is not cured nor relieved by this operation.

(2) *Exophthalmic goître.*—Jonnesco, of Bucharest, has reported wonderfully good results, tending to show that some forms of exophthalmic goître are due to irritation of the sympathetic. But a like success has not been obtained by others, and the operation is a dangerous one in this disease.

(3) *Glaucoma.*—It has been thought that spasm from sympathetic irritation causes the excess of intra-ocular tension. After division of the sympathetic some diminution of intra-ocular tension and of proptosis has been noted, but the effects are very uncertain and the good results do not persist.

(4) *Sympathetic pain.*—Paroxysmal attacks of pain, *migraine* or *megrims*, may arise in the eyeball or in the blood-vessels of the head. The painful sensations are conducted back through the cervical sympathetic to the central nervous system. The pain may radiate widely to the chest or arms. In cases of this kind an excision of the sympathetic ganglion and nerve has been most successful.

(5) *Fibrous enlargement* of the sympathetic ganglion, *fibroma* or *neuro-fibroma* resembling to the touch a deep-seated gland, but accompanied by signs of sympathetic irritation or paralysis.

Jonnesco has employed an incision along the posterior border of the sterno-mastoid; Burghard prefers an incision along the anterior border. The muscle is retracted, and the internal jugular vein included in the carotid sheath with the vagus nerve is drawn inwards. The superior cervical ganglion is found behind the vein, lying on the longus colli muscle, in front of the transverse processes of the second and third cervical vertebræ. The exposed ganglion is drawn forwards and cut away as high up and as low down as possible. When bilateral removal is required, it is much safer to do the opposite side after an interval of three weeks, rather than at the same sitting. Following excision there is some ptosis from paralysis of the superior palpebral muscle of Müller, severe pain and congestion of the vessels of the face, and, except in glaucoma, contraction of the pupil. These symptoms are transitory.

DISEASES OF THE MOUTH.

Stomatitis, or inflammation of the mouth, may be divided into the herpetic, the aphthous or parasitic, the ulcerative, the syphilitic, the mercurial and the gangrenous.

Herpetic stomatitis is characterised by the formation of vesicles on the inner surface of the lips or sides of the tongue, accompanied by smarting and neuralgic pains. The vesicles soon rupture, leaving an epidermal layer covering an excoriation. The layer of raised epidermis must be distinguished from the fibrinous adherent membrane of diphtheria and the curdy patch in thrush. Herpetic

stomatitis is generally of dyspeptic origin, and occurs especially in neurotic women. In older people it may be gouty. The pain is so great that the patient may have difficulty in eating. The attack quickly subsides, but soon recurs. The *treatment* consists in a mild mouth wash, the avoidance of all irritation, and the improvement of the general health.

Aphthous or parasitic stomatitis or Thrush.—The terms "thrush" and "aphthous" have in the past been loosely employed, but in accordance with the nomenclature adopted by the College of Physicians, they should be confined to the disease caused by the parasite, *Saccharomyces, vel Oidium albicans.* White, easily detached, curdy spots and patches appear in which the parasite may be found. Ulcers form beneath, and the mycelium of the parasite penetrates the epithelium. The disease may spread to the pharynx and œsophagus, and the ulcers may become foul or gangrenous. It usually occurs in young children, but may appear in exhausted adults. The affection may be very slight or prove fatal by setting up diarrhœa or septic absorption. It appears in badly-fed and badly-cared-for children, and may spread from one to the other by means of spoons and other feeding apparatus. It is especially introduced through milk. Borax and honey should be applied locally, and the general health attended to. It may be distinguished from the herpetic form by the mouth being dry, whereas in the latter it is always moist. The parasite, moreover, is situated in the middle layers of the epithelium, so that the superimposed layers can be peeled off. In the herpetic these cannot be removed except with pain and bleeding. The parasitic never affects columnar epithelium.

Ulcerative stomatitis is more serious, but is still, as a rule, superficial. It may depend upon digestive disturbance, local irritation of cutting teeth, or bad hygiene. The ulcers are covered with a grey slough, the gums are red and swollen, and the breath is foul. A stimulating plan of treatment is generally required, with attention to the digestive functions, hygienic surroundings, etc. Locally, the mouth should be rinsed out with a wash of chlorate of potash (gr. x. to ʒj.), and the foul ulcers painted twice a day carefully with bicyanide of mercury lotion (1 in 1,000) or other strong antiseptic.

Syphilitic stomatitis is common during the secondary and tertiary stages of syphilis, and requires no further mention.

Mercurial stomatitis, depending upon an overdose of mercury, absorption through the too energetic washing out of a wound with strong perchloride of mercury solution, or some idiosyncrasy of the patient to the drug, is of less frequent occurrence in its severe forms than formerly. It is attended with foul breath, swollen tongue, spongy gums, profuse salivation, swelling of the parotid and submaxillary glands, and loosening of the teeth. It may terminate in gangrenous ulceration, with extensive destruction of the soft tissues,

and perhaps necrosis of the bones. Chlorate of potash, both internally and as a mouth-wash, should be given; and the strength supported by fluid nourishment and, if indicated, by stimulants.

Gangrenous stomatitis, or *cancrum oris*, is a phagedenic ulceration, which begins on the inside of the cheek, and if not checked rapidly involves its whole thickness. It is very apt to terminate in blood-poisoning. It appears to depend upon thrombosis of the capillaries, a condition probably induced by the presence of a specific micro-organism (*? Lingard's bacillus*). Gangrenous stomatitis is most frequently met with in under-fed, debilitated children recovering from one of the exanthemata, as scarlet fever, etc., or subject to bad hygienic conditions. A foul and black slough preceded by great tenderness and fœtid breath forms in the mouth, and a dusky patch soon appears on the surface of the cheek, which becomes hard and brawny, and then black. The ulceration may extend to the gums, and if the disease is not soon arrested, extensive sloughing occurs, toxæmic symptoms set in, and the patient dies comatose, of general blood-poisoning, or of bronchitis or pneumonia; or he may recover, but with the loss of a large part of the cheek, leaving the mouth and pharynx exposed. It appears to be of a nature similar to the gangrenous inflammation of the female genitals known as noma. The *treatment* must be energetic. The parts should be well dried, and thoroughly destroyed with pure carbolic acid, or 1 in 500 perchloride of mercury, but weaker solutions may be applied in milder cases. If the gangrenous process is not arrested all the infected tissue should be cut away, portions of the jaw being gouged out if necessary. Free bleeding will show that healthy tissues have probably been reached. The chasm thus left is filled with iodoform gauze and may subsequently be closed by a plastic operation. The strength in the meanwhile must be supported with strong beef-tea, brandy-and-egg mixture and nutrient enemata. Opium internally is most useful, since it relieves the pain.

Xerostomia or dry mouth is the result of a diminished secretion of saliva and mucus, and is apparently of nervous origin. It generally occurs in women over fifty years of age. The lips are dry and scaly, the tongue fissured like crocodile's skin, the cheeks and gums glazed and covered with crusts. The teeth are carious and slowly crumble away. The parotid glands become swollen and painful, and the skin dry and harsh. Frequently a similar condition is met with in the nose and conjunctiva. The patient, in addition to dryness of the mouth, complains of loss of taste, only a strong solution of quinine being perceived, or of subjective sensations as a salt flavour in the mouth. *Treatment.*—Tonics and mouth-washes with removal of carious stumps, and the fitting in of suitable dentures. Sialogogues, such as pilocarpine, are useless, perhaps harmful.

may destroy all the projecting part of the tongue. *Treatment.*—Bands of adhesions should be divided if by doing so the tongue can be rendered more moveable.

Macroglossia, or hypertrophy of the tongue, may be congenital or acquired. Both are rare.

Congenital macroglossia occurs in two forms, the simple or muscular and the lymphangiomatous.

(*a*) *Simple or muscular macroglossia* is an enlargement of the tongue solely due to muscular hypertrophy. It occurs usually in patients of weak intellect, in idiots, and in subjects with general muscular hypertrophy. The hypertrophy may be unilateral and accompanied by hypertrophy of half the face or of half the body. The tongue lolls out of the mouth and may be ulcerated through the

FIG. 349.—Acquired macroglossia.

irritation of the teeth, but there are no vesicles on the surface, nor are there periodic attacks of inflammation.

(*b*) *Lymphangiomatous macroglossia* may affect part or the whole of the tongue. Thus it may take the form of a lymphatic nævus and then appears as a number of vesicles with bright red capillary loops between. The vesicles are translucent, red or blue, containing clear lymph or arterial or venous blood. They burst and discharge, leaving a raw surface. In the muscular substance there are lymphangiectases, *i.e.*, dilated lymph-spaces into which blood may be extravasated; there is an increase of fibrous tissue replacing muscular fibres, and in some places lymphomatous masses of small round cells. The tongue is subject to recurrent attacks of inflammation, each

by syphilis, excessive smoking, some forms of dyspepsia, the abuse of spirits, jagged teeth, etc. It begins as a hyperæmia of the papillary layer, and presents at this stage slightly raised red patches, better seen if the tongue be dried. This is followed by an excessive growth of epithelium, the cells of which assume a horny character and the patches which were previously red become bluish-white and later, opaque white. Several of the patches may now coalesce, covering in severe cases the whole or greater part of the dorsum of the tongue. It is this condition to which the term *psoriasis* has been applied, from its superficial resemblance to psoriasis of the skin. Still later, from excessive heaping up of the epithelium, the

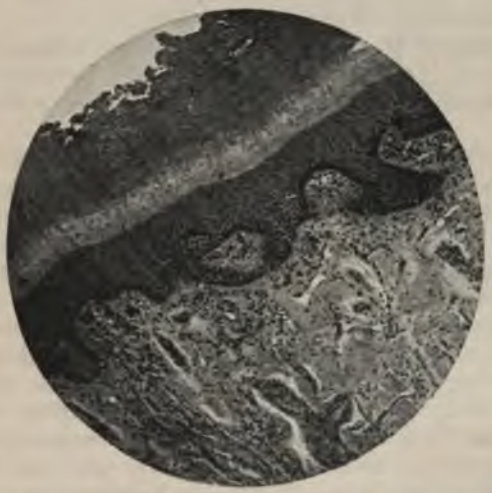


Fig. 350.—Chronic superficial glossitis, or leukokeratosis. Photograph of a vertical section through the epithelial surface showing great increase in the corneous layers, also some collection of leucocytes in the connective tissue and amongst the muscular fibres beneath. From a case of long standing which became epitheliomatous.

surface of the organ becomes cracked and nodular, simulating *ichthyosis*, a name by which it has also been called. As the pathology of the affection, however, is distinct from that of the above-named affections of the skin, it would be better to drop these terms, and to call the affection either *leukoplakia* (*white patches*), *leukokeratosis* in relation to the change in the epithelium, or simply *chronic superficial glossitis*. After variable periods, the hypertrophied papillæ may atrophy, or ulceration may occur; or the epithelium may grow down into the substance of the tongue and the disease become epitheliomatous. At times the inflammation does not give rise to an increase of epithelium, the tongue then appearing smooth, glazed, and red. The disease, except when ulceration occurs, causes little or no pain,

may follow wounds and operations, especially those involving the abdominal cavity. If the original source of the septic mischief yields toxins only, the parotitis may subside, but if there is septicæmia, diffuse suppuration with multilocular abscesses ensues, which, especially if bilateral, may end fatally.

Chronic parotitis causes an indolent enlargement of the whole gland. It may result from obstruction of the duct by a calculus, and the gland swells up, especially during mastication. It is also connected with xerostomia, or dry mouth (p. 733), the obstruction to the duct then being due to inspissated secretion. A chronic interstitial inflammation is set up, and a cyst or fistula may form. *Treatment.*—A calculus, if present, should be removed and a communication with the mouth formed as in the case of parotid fistula (p. 499). A cyst may be excised. When the enlargement is connected with xerostomia, massage may relieve.

Parotid abscess.—A circumscribed unilocular abscess may arise from suppuration in one of the lymphadenoid masses within the capsule of the parotid, as the result of cutaneous irritation or tuberculous disease, or may form around a calculus. *Treatment.*—The incision should be made horizontally to avoid dividing the facial nerve, and should not extend as far back as the temporal artery.

Diffuse suppuration follows acute septic parotitis (see above), and is pyæmic in origin. A brawny mass forms on one or both sides. *Treatment.*—An incision should be made, which must not extend behind the line of the jaw, as much of the inflammatory material as possible scraped away, and the cavity swabbed out with a strong antiseptic and plugged with gauze or fomented. This must be done quite early or the patient will die of septicæmia.

Parotid tumours.—Both innocent and malignant tumours may occur in the parotid gland. The *innocent* tumours generally affect one lobe or the superficial part of the gland. They are encapsuled, grow slowly, press aside the rest of the parotid, which becomes atrophied but is otherwise unaltered, shell out freely, and if removed do not recur. If left alone they may attain a large size in the course of years. Many forms of innocent parotid tumours have been described, as fibrous, adenomatous, myxomatous, and cartilaginous; but the tumour so commonly met with in this situation has a mixed structure, and was formerly spoken of as consisting of cartilage intermixed with fibrous and myxomatous tissue and with atrophied glandular elements. The more likely view, however, is that which classes it as an endothelioma derived from the endothelium of lymphatics and capillaries (Fig. 45). The growth of the endothelial cells fills the lymphatic vessels and spaces with a hyaline substance, which thus has a tubular arrangement, and has been called cartilage, but bears only a superficial resemblance to that substance. Some of the cells may be developed into fibrous tissue, whilst others undergo mucoid degeneration. The endothelium of the capillaries may develop and form fresh blood-

channels, hence giving the tumour a nævoid or angiomatous structure. One or other of these types of tissue may especially predominate, or all may be found in different parts of the same tumour. Cystic degeneration is not uncommon. The view formerly held, that the tissue resembling cartilage is derived from the elements of the rudimentary fœtal structure concerned in the development of the lower jaw, and known as Meckel's cartilage, is thus superseded. *Malignant tumours.*—The sarcomata and carcinomata, when they occur in the parotid, soon affect the whole gland, extending deeply amongst the important structures behind the ramus of the jaw and about the styloid and mastoid processes. Thus, the carotid vessels and the facial nerve may become surrounded, and even the walls of the pharynx be encroached upon.

Symptoms and diagnosis.—The differential diagnosis of the various parotid tumours cannot be here attempted. Nor is it of consequence, as it is often impossible before removal to determine their exact nature. The practical points for the surgeon to consider are: Is the growth innocent or malignant? Can it be safely removed? *Innocent tumours* grow slowly, and are at first freely moveable, smooth, or slightly lobulated, circumscribed, hard and firm, or semi-elastic; but as they increase in size they may become soft or fluctuating in places, either from mucoid softening or cystic degeneration. The skin over them, though stretched and thinned, is non-adherent, and the glands are not affected. *Malignant tumours*, on the other hand, grow rapidly, are ill-defined in outline, bossy or nodular, generally soft or semi-fluctuating, and become firmly fixed to the surrounding parts; the skin is adherent, purplish-red, brawny, infiltrated with the growth, and later ulcerated; and the lymphatic glands are enlarged. Facial paralysis from involvement of the facial nerve is not uncommon. An innocent tumour, however, after having grown slowly for many years, may suddenly take on rapid growth and malignant characters.

Treatment.—When the tumour appears innocent, of moderate size and freely moveable, indicating that its attachments are not deep, there can be no question about its excision. But when of very large size, especially if firmly fixed to surrounding parts, or if malignant, unless quite small and the skin and glands are not to any extent involved, it should be left alone. *The Operation.*—Make a free longitudinal incision through the skin and fascia to thoroughly expose the tumour; it will then often readily shell out of its capsule. If not, draw it forward with a volsella, and separate its deeper attachments with the handle of the scalpel and occasional touches of the knife, the edge of which should be turned towards the tumour to avoid the branches of the facial nerve and other important structures. The proximity of the carotids should not be forgotten, but the chief point to remember, perhaps, is *to keep close* to the tumour so as to avoid the facial nerve.

DISEASES OF THE NECK.

Inflammation and abscess in the neck are attended by the same signs as elsewhere. Unless quite superficial, when a free incision is made, the abscess is best opened by Hilton's method.

Ludwig's angina is an acute infective inflammation of the cellular tissue of the neck, and occurs beneath the deep cervical fascia. It is generally secondary to some septic inflammation in the mouth or pharynx or more rarely in the lower jaw or temporal bone. It is characterised by a brawny induration of the neck, generally beginning below the lower jaw and thence spreading towards the middle line or opposite side of the neck, and downwards to the mediastina and pleura. The skin becomes dusky red and œdematous, and the deeper tissues infiltrated with serum and pus, leading to the formation of multiple abscesses and sloughing of the tissues. It is attended by acute fever which gradually assumes an asthenic type. It is often rapidly fatal, the patient dying of general blood poisoning, septic pneumonia, syncope, or œdematous laryngitis. *Treatment.*—Free incisions through the fascia should be made, the strength supported by fluid nourishments and stimulants, and tracheotomy performed as soon as the larynx becomes involved. The administration of streptococcal antitoxin is of vital importance in the case of a pure injection by streptococci.

Enlargement of the lymphatic glands is very common, and may be due to irritation, glandular fever (see p. 437), tubercle, lymphadenoma, syphilis, diphtheria, and malignant disease. In enlargement secondary to irritation or to malignant disease—the *submental glands* are affected when the primary trouble is in the lips or front of the mouth; the *submaxillary* when in the tongue, side of the mouth, nose and face; the *sterno-mastoid* when in the tonsil, fauces, pharynx and middle ear; the *carotid* when in the lower part of the pharynx, larynx, neck, or upper part of the thorax; and the *post-cervical* when in the scalp. Tuberculous and lymphadenomatous diseases of the glands are described under *Lymphatics* (p. 435).

Branchial fistulæ are produced by the imperfect closure of the branchial clefts, and may therefore be met with in the region of any of the clefts. They are lined with columnar-celled epithelium, and usually open externally along the anterior border of the sterno-mastoid, and internally into the pharynx, generally behind and below the tonsil; but there may be no internal opening. They secrete a glairy mucoid fluid, which exudes, or can be made to do so on pressure, from the mouth of the fistula, which is generally of the size to admit a small probe. At times a little within the external opening the fistula becomes dilated into a distinct cyst, from which fluid can be squeezed out. Branchial fistulæ are often associated with other abnormalities depending on the imperfect development of the branchial clefts,

such as *auricular appendages.* These, which are situated near the dorsal and ventral ends of the clefts, consist of little flaps of skin containing cartilage. *Treatment.*—The fistula should be completely dissected out, the internal opening invaginated, closed by suture and the skin margins carefully united. If this is not done carcinoma may arise later.

Exostosis of the seventh cervical vertebra.—The anterior part of the transverse process of the seventh cervical vertebra, namely, that part which is in front of the vertebral foramen and is homologous to the cervical ribs of some animals, may become enlarged, forming a nodular exostosis, or it may be developed into a true rib. It projects in the supra-clavicular triangle, and may give rise to pain or tingling in the arm, forearm or hand, paresis or even paralysis from pressure on the brachial plexus, œdema from pressure on the subclavian vein and diminution of the pulse at the wrist from pressure on the subclavian artery. *Treatment.*—If it causes no symptoms it is left alone; otherwise it is exposed by an incision over it, the soft tissues peeled off, and the peduncle divided by bone-forceps or saw.

Cysts met with in the neck are: I. Unilocular cysts or hydroceles of the neck; II. Multilocular cysts or cystic hygromata; III. Branchial cysts; IV. Dermoid cysts; V. Thyroglossal cysts; VI. Blood cysts, and VII. Cysts containing air, or aeroceles.

I. *Hydrocele of the neck* is a single, painless, translucent, smooth-walled unilocular cyst, containing serous fluid and formed by the congenital distension of connective-tissue spaces. It is situated behind the sterno-mastoid, whereas thyroid cysts and dermoids are in front of that muscle. *Treatment.*—It can be readily shelled out.

II. *Hygromata or multilocular cystic tumours* arise in the deep cervical fascia, are lined by endothelium, and contain a serous fluid with some shed cells and cholesterin crystals. There is a variable amount of œdematous intercystic connective tissue. They appear as soft, lobulated, doughy, elastic tumours in front of or behind the sterno-mastoid, on one or both sides of the neck in children of a few months old (Fig. 344). They enlarge in size, and extend in the course of the prolongation of the deep fascia towards the trachea or into the anterior mediastinum, causing dyspnœa, or under the clavicle into the axilla. Extravasations of blood and inflammation sometimes spontaneously occur, but inflammation or suppuration is more likely to be due to injudicious methods of treatment. They must be distinguished from the mucous cysts occurring in the thyroglossal tract, the dermoid cysts lined by stratified epithelium, and the branchial cysts lined by columnar-celled epithelium, also from the cysts arising in connection with the thymus. *Treatment.*—The methods used are injections of iodine, and partial or total excision. The last is the best, but considering the tender age of the patient can only be carried out in early and limited cases. Partial excision

mouth, and inwards to the opposite half of the tongue; whilst the submaxillary lymphatic glands, and later the lymphatic glands in the neck, become enlarged, and the parts about the angle of the jaw infiltrated and matted together by the disease. Secondary ulcers then form from the breaking down of the glands in the neck, septic absorption occurs, and the patient dies, worn out by pain and irritation, or exhausted by hæmorrhage; but like squamous carcinoma in other parts, it seldom becomes disseminated in distant organs.

The glands involved in epithelioma of the tongue and floor of the mouth.—In epithelioma of the anterior third of the tongue, anterior part of the floor of the mouth and frænum the submental glands below the chin on the mylo-hyoid muscle are involved. From these glands lymphatic vessels pass to the lower deep cervical glands in front of the first part of the subclavian artery above and behind the clavicle. In epithelioma of the middle and posterior part of the tongue and corresponding part of the floor of the mouth the submaxillary lymphatic glands in the digastric triangle are first affected; some of these are attached to the capsule of the submaxillary salivary gland, and some lie in the septum between it and the parotid. From these glands lymphatic vessels pass to the upper deep cervical glands, a chain lying over the internal jugular vein beneath the anterior edge of the sterno-mastoid and extending from the mastoid process to the spot where the omohyoid crosses the great vessels. Some of the lymphatic vessels from the middle and posterior third of the tongue pass direct into this chain. The chief and earliest glands of the deep cervical set to be affected are those about the level of the thyroid cartilage, but all may be nearly equally involved from the mastoid process to the clavicle.

Treatment.—Early and free extirpation ought in every instance to be undertaken, together with the glands in the neck which are liable to be involved, even although they do not appear to be implicated. When the disease has attained some magnitude, the propriety of removal becomes a question, and opinions differ under what circumstances it ought to be attempted. Its removal is a severe operation: (1) when it has extended so far backwards that the finger cannot reach healthy tissue beyond it; (2) when it is firmly and extensively adherent to the jaw; and (3) when the tongue is firmly bound down to the floor of the mouth. No operation should be done when the glands, not only below the jaw, but deep in the neck, are much enlarged, implicating the carotid and vagus, and when the patient is too weak, or enfeebled by age, or emaciated from the disease itself or from disease of other organs. Moderate enlargement of the glands, slight adhesion to the jaw, and some infiltration of the floor of the mouth, do not forbid an operation (especially if the patient is suffering from much pain, and is otherwise in good health), provided the whole of the disease with the

the mouth and one below the chin fluctuation will be obtained. They are apt to suppurate and then burst and form a persistent sinus, but they do not become the seat of malignant disease as do dermoid cysts elsewhere. *Treatment.*—The cyst should as a rule be excised by a median incision below the chin, and unless inflammatory complications have involved the wall and surrounding tissues, can be shelled out completely without endangering the lingual arteries. When these cysts are of small size, freely moveable, and project distinctly under the tongue, they may be shelled out with the greatest ease through an incision in the mucous membrane of the floor of the mouth, thus avoiding an external scar and without any danger from hæmorrhage or sepsis. We have treated many in this way.

V. *Thyro-glossal tumours and cysts.*—These tumours are enlargements of outlying portions of the thyroid gland, and in some cases are the only portions of the gland existing, the thyroid being absent from its usual situation, so that cachexia strumapriva, or operative myxœdema, has followed the complete removal of a thyroid tumour situated in the position of the foramen cæcum. The cysts which occur are secondary, just as cysts in the thyroid gland are secondary to adenomata. They are therefore neither "Ranulæ" nor "Dermoids." The tumours arise in the thyro-glossal tract of His. His called it a tract: there is no evidence of a duct. This tract takes part in the formation of the isthmus, the pyramidal lobe and adjacent portions of the lateral lobes of the thyroid gland. The line of the tract is from the foramen cæcum down to the body of the hyoid bone, thence in front of the thyro-hyoid ligament beneath the muscles to the pyramidal lobe and isthmus. Occasionally and especially in goîtrous districts thyroid tissue is found in this tract, and at the foramen cæcum, a shallow depression lined by stratified epithelium into which mucous glands open. Hence a thyro-glossal tumour or cyst may be met with (a) in the tongue in the position of the foramen cæcum, and (b) in the neck near the body of the hyoid bone (connected with the periosteum, or actually in the bone itself), or in front of the thyro-hyoid ligament behind the septum uniting the sterno-hyoid muscles.

(*a*) *A thyroid tumour at the foramen cæcum* forms a dark red mass the size of a nut, and is characterised especially by recurring, and even severe, hæmorrhages. It is not indurated, nor does it develop or ulcerate like a malignant growth. From an enlargement of the lingual tonsil, *i.e.*, a swelling of the numerous lymph nodules at the base of the tongue, it is known by the latter being situated behind the foramen cæcum, and not being accompanied by hæmorrhage. A cyst may form secondary to the tumour by degeneration. The *diagnosis* is confirmed by examining microscopically a piece of the tumour or cyst, when typical thyroid gland acini will be found. *Treatment.*—The tumour is removed by opening the mouth with a

tip, and the mucous membrane, where it is reflected from the tongue to the jaw, is divided with scissors along with some of the fibres of the genio-hyo-glossus. The mucous membrane covering the dorsum of the tongue is next divided in the middle line by a bistoury from the tip as far back as to be well beyond the disease. This allows the tongue to be readily split with the fingers into two halves. The diseased half is separated from its attachments, beginning from below by a series of short snips with blunt-pointed scissors, clamping or tying the lingual artery, if seen, before it is divided, or else immediately it is cut. The lingual artery lies just below the muscle substance about a quarter of an inch from the middle line. If the disease involves both sides of the tongue the opposite half can next be removed in the same way. To prevent hæmorrhage during the operation, some surgeons first tie one or both lingual arteries in the neck, whilst others, for fear of blood entering the trachea, perform tracheotomy, and plug the trachea with Hahn's tampon cannula, or merely introduce an ordinary tracheotomy tube, and plug the pharynx firmly with a sponge during the operation. All such measures are, however, quite unnecessary in the more limited operation, and may add to its danger. Should bleeding occur it can always be arrested temporarily by merely passing the finger into the pharynx and pressing the tongue against the inner surface of the jaw, and then as soon as the mouth has been sponged clear of blood the bleeding vessel can be seized and tied.

Whitehead's method is attended by a very small mortality. It fails, however, in most cases to prolong life beyond a year or so, owing to the continued development of the disease in the glands. Even when the glands cannot be felt enlarged before the operation, they may be found so on dividing the deep fascia, especially those along the jugular vein. The examination of glands not enlarged to the naked eye may result in finding the commencement of epithelioma. Hence it has become increasingly common to remove the glands in the neck, although not clearly enlarged. This may be done at the same time, but is often postponed for three weeks until the tongue has healed. The objection to the latter plan is that patients are unwilling to undergo a second operation until it is too late. They think of the second in the light of the first ordeal, although they suffer from the second very little, owing to the aseptic character of the operation.

The operation will be facilitated when the disease is far back by splitting the cheek from the angle of the mouth to the masseter muscle; whilst, if the disease has invaded the bone, the lower lip may be vertically divided in the middle line, the incision continued on each side for a short distance along the lower border of the ramus of the jaw, the soft parts dissected up, and the infiltrated bone removed by the saw or bone-pliers. Division of the lower jaw in the middle line and separation of the two halves is a useful procedure

with the branchial clefts. They occur as hard, solid tumours, and pursue the course of malignant disease elsewhere.

Wry-neck or torticollis is a distortion chiefly dependent upon contraction of the sterno-mastoid muscle. It may be congenital or acquired.

Causes.—The *congenital form* is attributed to—(1) injury at birth, as, for example, rupture of the sterno-mastoid in a breech presentation; (2) malposition *in utero;* or (3) spastic contraction of the sterno-mastoid muscle due to disease of the nervous system. The *acquired form* is due to—(1) the head having been held for a long time in the distorted position as a consequence of stiff neck following cold, rheumatism, injury, or enlarged cervical glands due to the irritation of parasites on the scalp or carious teeth; (2) hysteria; or (3) spasm set up by irritation of the spinal accessory nerve consequent upon central nerve trouble.

Signs.—The head, supposing the right sterno-mastoid to be affected, is drawn forwards and towards the right shoulder and also rotated, so that the chin points to the left. The right mastoid is prominent, the right side of the neck concave, and the left convex. In long-standing cases some compensating lateral curvature of the dorsal spine is generally acquired. The congenital form may be distinguished from the spasmodic not only by its history but by the sterno-mastoid becoming tense in the former, and yielding in the latter, on attempting to straighten the head. The hysterical variety will be known by the presence of other signs of hysteria.

Treatment.—In *congenital wry-neck*, unless the patient is treated by position while still an infant, division of the sterno-mastoid is generally required, followed by a course of systematic exercises in the slighter cases, and the use of some such instrument as that shown in Fig. 345, in the most severe. The exercises consist in passive and active movements in directions opposite to the deformity. The sterno-mastoid is best divided immediately above the clavicle, as here it is furthest removed from the important structures that lie beneath it. A puncture should be made at the inner side of the tendon, a director passed behind it, and the division made towards the skin with a blunt-pointed tenotome. If now on stretching the muscle the clavicular portion becomes prominent, it should be divided in the same manner through a puncture at the outer border of the clavicular portion. The bands of contracted fascia which now start forward will readily yield to stretching the neck; it is not safe to divide them. In some cases the upper aponeurotic end of the mastoid should be divided at the same time as the tendon through a subcutaneous puncture at the inner border of the muscle immediately below its insertion into the mastoid process. After the operation the head should be placed in a position of over-correction and thus held by a bandage and sand-bags for a week or more. As soon as the puncture is healed, *i.e.*, after a week, the exercises are begun and

the instrument is applied to counteract the tendency to re-contraction. Some advise the excision of the scar about the middle of the muscle on the plea that such is a more safe procedure; whilst others again recommend the division of the tendon through an open incision, as in this way the danger of puncturing and admitting air into a vein is avoided. Spencer makes a short incision to the inner side of the tendon, draws the tendon into the wound with a blunt hook, and then divides it with a probe-pointed tenotome. If the subcutaneous division, however, is carefully done in the manner here advised, Walsham does not believe there need be any fear of air entering the veins. He has now performed this little operation many times, and has never experienced any difficulty or trouble. It is only right, however, to state that sudden death has occurred in the hands of

Fig. 345.—Wry-neck apparatus.

some surgeons, and others have met with alarming symptoms. In *spasmodic* cases the cause of the reflex irritation should, if possible, be removed and conium, Indian hemp, bromide of potassium, etc., be tried. These failing, the spinal accessory nerve may be stretched just above the spot where it enters the sterno-mastoid. In very intractable cases a piece of the nerve may be excised, and if the posterior cervical muscles are also involved in the spasm, excision of portions of the posterior divisions of the first four cervical nerves may be simultaneously or subsequently undertaken. A flap is turned down from the hairy scalp by an incision which is prolonged down the posterior border of the sterno-mastoid, and the nerves sought for at their exit from the muscles and traced to the intervertebral foramina. Tenotomy of the sterno-mastoid should in spasmodic and in hysterical cases on no account be done. In the latter, hysterical remedies should of course be used.

DISEASES OF THE THYROID AND THYMUS GLAND.

Bronchocele, goître, or Derbyshire neck is an enlargement of the thyroid gland (Figs. 346, 347). It may be due, as is commonly the case, to simple hypertrophy of the normal tissues of the organ

FIG. 347.

FIG. 346.

FIGS. 346 and 347.—Bronchocele or Goître. (Photographs copied, by kind permission, from Mr. James Berry's "Diseases of the Thyroid Gland.")

(*ordinary or parenchymatous goître*), and may then involve the whole gland or one of the lateral lobes, or rarely only the isthmus. In other instances, the hypertrophy may fall chiefly on the fibrous tissue constituting the septa of the gland (*fibrous goître*). Or along with some amount of simple hypertrophy and increase of fibrous

but no such bursa exists, and the contents of the ranula is like the others—glairy mucus, not serous fluid. *Treatment.*—A seton may be passed through the cyst, or a piece of the wall pinched up and cut away with scissors after the surface has been painted with cocain. These methods only cure very early cases. The interior may be rubbed with nitrate of silver or a strong antiseptic, and filled daily with a strip of gauze, but this process is somewhat painful and may be unsuccessful. The best method for a ranula of some standing is to dissect it out under a general anæsthetic through the mouth. Attempts to do so by the cocain infiltration method are likely to be imperfect, and then there is a re-formation of the cyst.

Dermoid cysts of the floor of the mouth (see p. 720).

Epithelioma of the floor of the mouth either about the frænum or between the tongue and the gums is not very uncommon. The epithelioma, whilst quite small and perhaps still unperceived by the patient, may be attended by considerable enlargement of the glands in the neck. Indeed, it is often for the glandular enlargement that surgical aid is first sought. A small ulcer with everted and indurated edges is discovered, perhaps not larger than a grain of wheat, whilst a large mass is present in the neck. The prognosis is very unfavourable. If the glands are not too extensively implicated they should be removed together with the ulcer, and if necessary half of the tongue and the affected part of floor of the mouth.

Tumours in the submaxillary gland are similar to, but rarer than those which occur in the parotid gland (which see).

DISEASES OF THE UVULA, PALATE, FAUCES, AND TONSILS.

Uvulitis, or inflammation of the uvula, is a frequent accompaniment of pharyngeal catarrh. The uvula appears red, swollen, and œdematous, and often considerably elongated. If the inflammation does not yield to the remedies employed for the catarrh, scarification should be practised.

Elongation of the uvula may depend upon chronic catarrh of the pharynx, or upon conditions similar to those leading to chronic enlargement of the tonsils. The elongated uvula may come into contact with the back of the tongue or even with the mucous membrane of the larynx, and in either case is productive of a troublesome tickling cough. If astringents fail, the end of the uvula may be amputated.

Cleft palate is a congenital defect due to an arrest of development of the processes which normally grow inwards from the superior maxillary and palate bones, and meeting each other and the vomer in the middle line, and the intermaxillary bone in front, form the hard and soft palate. This arrest of development may be complete, the fissure extending in the middle line through the uvula and the

p. 301). It also occurs sporadically; and in some cases again is accompanied by a peculiar jerking beat in the carotids, by anæmia, and by a prominence of the eyeballs (*exophthalmic goître*) for a full account of which a work on Medicine must be consulted.

The *symptom* common to any form of enlargement of the thyroid is a swelling taking more or less the characteristic shape of the thyroid gland, and moving with the larynx in deglutition. In this country the enlargement is generally moderate; but sometimes, and especially in Switzerland, the goître forms a large mass hanging down in front of the neck, and may press upon, or even displace, the trachea or œsophagus. It occurs chiefly in women. The *ordinary or parenchymatous* variety is soft, elastic, semi-fluctuating, and of uniform consistency. The *fibrous* is firm and hard and more or less lobed or irregular, and where calcification has taken place, of stony hardness. This form especially compresses the trachea, softening the tracheal cartilages, reducing the trachea to a fibrous tube of the shape of a scabbard, the inextensile isthmus holding the lateral lobes together. *Cystic goître* usually occurs as a globular, smooth, uniform, and fluctuating swelling confined to one lobe of the gland, and may be difficult to distinguish from an *adenoma* which gives rise to a similar swelling save that it does not fluctuate. *Malignant goître*, which is rarer, may be known by rapid growth, enlarged glands, and the other signs of malignancy mentioned at p. 139. If dissemination occurs the secondary growths resemble thyroid gland tissue. Such growths have been met with in the bones of the skull.

The *cause* of endemic goître is not known, but is in some way connected with impure water. The water supplied to certain villages, also certain wells, give rise to goître, whilst in the same district there may be watercourses, springs and wells which do not cause the disease. It is said to be most prevalent in valleys where, from their direction, the sun does not penetrate, on damp soil, and in damp parts of towns, but according to Mr. Berry these influences have little or nothing to do with its causation. In sporadic cases, heredity, disturbance of the sexual functions, and conditions producing congestion of the head and neck, are given as causes. Recently it has been shown that the active principle in the thyroid secretion is an albuminous compound containing iodine (*thyro-iodine*), and it is suggested that the cause of goître may be the absence of iodine in the system and the compensating hypertrophy of the gland.

Treatment.—Sporadic cases of ordinary goître have hitherto been generally treated by the internal and external application of iodine. Thus the syrup of the iodide of iron may be given internally and an ointment of iodine and iodide of potassium applied externally. The use of biniodide of mercury ointment, followed by exposure to a hot sun, has been much praised in

excised if enlarged, adenoids if present removed, and a time selected for the operation when the weather is mild and the child is free from cough or cold.

Staphylorrhaphy or closure of the soft palate.—Chloroform having been given by Junker's apparatus with the tube passed through the nose, and the mouth widely opened by a Smith's gag, which depresses

Fig. 356.—Smith's palate needle for passing horsehair sutures in cleft palate.

the tongue at the same time (Fig. 354), one end of the bifid uvula is seized with long forceps, and the edge of the cleft pared from below upwards, and the paring repeated on the opposite side. The uvula and the lower part of the palate are then united with horsehair, the upper part with silver wire. The wire sutures are best passed by Smith's needle, by which they can be carried through

Fig. 357.—Suture-catcher.

both sides of the cleft by one transit of the needle. This needle, shown in Fig. 355, has "a small reel attached behind the handle to hold the wire, and a small serrated wheel half-way up the handle to protrude the wire from its tubular point." The horsehair may be passed across the cleft by the needle shown in Fig. 356, and as the point of the needle protrudes from the palate, the end of the horsehair is seized and drawn out by nibbed palate forceps or by the suture-catcher (Fig. 357), and the needle withdrawn. The silver

Fig. 358.—Wire-twister.

sutures should be fastened by the wire-twister (Fig. 358) and cut off short, care being taken to hold the edges of the cleft merely in apposition and not to apply any tension. The horsehair should be tied with a surgeon's knot. When the parts have been brought together any undue tension should be relieved by making lateral incisions through each side of the soft palate parallel to the cleft and just internal to the hamular process with a tenotome on a long handle. The incision should begin at the hinder end of E (Fig. 359). By these incisions the levator palati muscles are divided. The palato-pharyngei may also be divided if necessary by notching the posterior pillars of the fauces with scissors.

Uranoplasty, or closure of the hard palate.—An incision from a quarter to three-quarters of an inch long should be made on either side of, and parallel to, the cleft through the muco-periosteum down to the bone (Fig. 359, E, E). The incisions should fall a little distance from the alveolar process, so as to avoid wounding the anterior palatine artery. Into one of these incisions a raspatory or an aneurysm needle with a short curve should be introduced, and the muco-periosteum separated from the bone along the whole length of the cleft in the hard palate, avoiding the neighbourhood of the posterior palatine foramen through which the anterior palatine artery runs. The attachment of the muco-periosteum to the posterior margin of the hard palate should be divided with curved scissors passed through the cleft and behind the soft palate, which should be drawn forwards to facilitate this step of the operation. Pressure should be made upon the parts with a small sponge by an assistant, whilst the muco-periosteum is being separated in like manner on the opposite side. The edges of the cleft had better not be pared until this stage of the operation, since now no bleeding will occur. Wire sutures should next be passed in the way described for uniting the soft palate, and any tension relieved by prolonging the cuts made for the introduction of the raspatory forwards or backwards as the case may require. Hæmorrhage, though often sharp, is seldom severe, and may generally be stopped by pressure or syringing with ice-cold water, the head being turned over to one side to let the blood escape, or if it becomes serious, by plugging the posterior palatine canal with a small peg of wood.

FIG. 359.—Position of the lateral incisions, E, E, through the muco-periosteum, in the operation for cleft of hard palate. The dotted line indicates the line of junction of the hard and soft palate. (Bryant's Surgery.)

Mr. Davies-Colley closes the cleft by raising two flaps of muco-periosteum on each side of the cleft; one flap having its base along the margin of the cleft, he turns over with the raw surface mouthwards, and fixes it by sutures to the opposite margin of the cleft; the other flap having its base at the junction of the hard and soft palate, he slides across the first flap so that their raw surfaces are in contact, and fixes it thus by sutures.

Mr. Arbuthnot Lane follows on the lines of Mr. Davies-Colley's operation. He uses fine curved needles and a needle-holder. He and Wolff, of Berlin, in particular have urged that the cleft palate should be closed in infancy. Lane closes the cleft palate first, taking advantage of the additional room afforded by the hare-lip, which he closes subsequently to the palate. Wolff advised operation in two stages—(1) The freeing of the flaps; and (2)

their suture a week later. These surgeons argue that even if there is a mortality from the operation in infants under six months of 10 per cent., yet that more than this number die if the palate be left to the ordinary age for operation. But one cannot ascribe all the mortality in the unoperated children to the cleft palate.

After-treatment.—The child, before the operation, should have got to know its nurse, who must try to keep it from crying and talking. The mouth need not be looked at for a week. If old enough it should wash its mouth out with permanganate solution after food. It should be fed on fluids for the first few days, and then on soft food for a fortnight. The sutures may be left in for three weeks or a month; if the child is unruly they should be removed under chloroform. The cleft ought to heal by the first intention, and the lateral cuts for taking off tension, by granulation. If a portion of the cleft fails to unite by the first intention it will often heal up subsequently by granulation; if not, a second operation must be undertaken. Owen advises that this second operation should be undertaken early—that is, whilst, as he thinks, the patient is immune to the ravages of the staphylococcus. It is somewhat doubtful whether the muco-periosteum ossifies. The child must be taught to speak properly, especially by watching and imitating the movements of his teacher's lips. In inoperable cases an obturator may be fitted by a dental surgeon so as to close the gap.

Necrosis of the hard palate is generally due to the breaking down of syphilitic gummata, and is followed by perforation and, at times, by destruction of the greater part of the hard and soft palate and septum of the nose. *Treatment.*—Large doses of iodide of potassium, and when the ulceration has ceased, an obturator to close the perforation, and later a plastic operation if practicable.

Tumours of the palate.—*Innocent tumours*, the so-called *adenomata* of the palate, are not so very uncommon. They occur as smooth, rounded, prominent, firm or elastic swellings, and readily shell out when an incision is made through the mucous membrane covering them. *Sarcomata and Carcinomata* are less frequently met with, and may be distinguished from the innocent tumours by their rapid growth, fixity, extension towards the fauces and tonsils, by the mucous membrane being adherent, and the glands at the angle of the jaw being enlarged.

Acute tonsilitis may be the result of taking cold in a person in feeble health or the subject of the rheumatic diathesis, or who from previous attacks has become predisposed to the disease; sometimes it is due to septic poisoning, as from the inhalation of sewer gas; or it may occur in the course of other diseases, as scarlet fever. *Signs.*—It generally begins with a slight chill, or even a rigor, followed by high temperature, furred tongue, offensive

breath, salivation, pain darting to the ear and increased on swallowing, and swelling of the glands behind the angle of the jaw. If the mouth can be sufficiently opened one or both of the tonsils are found to be red and swollen, and often in contact, blocking up the fauces. The neighbouring parts of the palate and fauces are congested and swollen. The inflammation may now subside, or terminate in suppuration (*quinsy*). *Treatment.*—At the onset a sharp purge should be given, while large doses of salicylate of soda, with the free use of solids of bicarbonate of soda put into the mouth by the patient with his finger, may be tried as abortives. When very acute the patient may take aconite tincture (B.P.) 5 minims every hour, until there is tingling and numbness, and if he can open his mouth his fauces may be painted with cocain, 10 to 20 per cent. Where suppuration threatens, the throat should be steamed, and hot camomile mattresses or boric-acid fomentations with opium applied externally.

Tonsillar abscess forms in a crypt of the tonsil which has become closed. Its development is attended by malaise and marked rise of temperature, great pain in swallowing the ropy saliva, and tenderness of the glands below the jaw. An indurated swelling which goes on to fluctuation forms, being most prominent at the junction of the palate and tonsil. At first the *treatment* is the same as for acute tonsilitis. The abscess usually develops on one side; hence a swelling which does not recede, but increases on one side with throbbing pain, should be punctured after painting with cocain, by a guarded bistoury about the junction of the soft palate and tonsil, and the cut made inwards. Relief rapidly follows. The bistoury is guarded nearly to its tip by wrapping a strip of strapping round it, and the cut is made inwards to avoid the tonsillar arteries.

Follicular tonsilitis occurs especially in young adults who are anæmic or live in close rooms and use their voice much, such as singers and clergymen. An overgrowth of the epidermis lining the follicles (*keratosis*) forms a hard whitish concretion, distending the crypt, and the epithelial cells are mixed with the mycelium of a mould. The local *treatment* consists in scooping out the concretions with a curette and wiping out the crypts with an antiseptic. Sometimes the keratosis and mycoderma form continuous patches covering the tonsils and extending beyond. These are painted with increasing strengths of salicylic acid, commencing with 5 per cent.

Chronic enlargement of the tonsils consists of an hypertrophy of the normal tissue of the tonsil, and is very common in delicate children, in whom it is frequently associated with adenoid growths in the vault of the pharynx, and follows oft-repeated attacks of acute tonsilitis. The crypts may be deep and full of concretions. The *symptoms* to which it may give rise are: a nasal

tone of voice; a peculiar vacant expression, acquired by the child constantly breathing with the mouth half open, regurgitation of fluids through the nose, snoring during sleep, distressing dreams, from the imperfect aëration of the blood, and recurring attacks of acute or subacute tonsilitis; whilst deafness, from implication of the Eustachian tube and middle ear in the chronic inflammation, may sometimes be induced, and even an alteration in the shape of the chest, and possibly phthisis. The tonsils appear irregularly

Fig. 360.—Mackenzie's tonsil guillotine.

enlarged, often almost blocking up the fauces, but, unless inflamed, of a natural colour, or perhaps slightly paler than natural. *Treatment.*—In young children attention to the general health, exercise in the fresh air, whilst avoiding causes of recurrent catarrhal attacks, and especially drill to enforce nose-breathing and development of the chest, may end in a cure. Iodine and catechu in glycerine or perchloride of iron may be used as a paint. In older subjects, where the tonsils have become permanently enlarged and show deep

Fig. 361.—Tonsil guillotine.

crypts full of débris, removal is indicated. Generally, tonsillotomy should consist in removing the projecting part of the tonsils by means of a tonsillotome or guillotine, the tonsils being first painted with cocain. In the case of children it is better to employ a general anæsthetic, but this is not absolutely necessary unless there are adenoids to be removed as well. The guillotine (Fig. 361) can be used by depressing the tongue, illuminating the tonsil by a head mirror, slipping the cutting ring over the tonsil, pushing the prong into the tonsil by means of the thumb ring, and then

drawing the cutting ring back by the two finger rings. The spade guillotine (Fig. 360) has, in Mackenzie's form, a convex cutting edge, in Morrison's a concave one. If a general anæsthetic is not used, the nurse should hold the child in her lap, keeping down its arms, whilst an assistant steadies and slightly retracts the head, at the same time making firm pressure inwards immediately below the angle of the jaw. The child is then induced to open the mouth by compressing the nose, when the guillotine with the spade drawn back is slipped into the mouth and over the projecting tonsil. The pharyngeal irritation causes the child to open the mouth widely, and so the tonsil bulges inwards, the forefinger feels that the ring is well over the tonsil, whilst keeping the tongue out of the way, the thumb of the hand holding the guillotine quickly pushes the spade home, and the finger in the mouth hooks out the excised tonsil. A little practice is required to hold the guillotine steady whilst pushing with the thumb; but it is much better to do the operation under an anæsthetic, as the above procedure unnecessarily terrorises the child. Some use an écraseur with either a cold or hot wire. The older method was to shell out the whole tonsil with the finger. In adults, when the tonsil is flat and undermines the pillars of the fauces, a general anæsthetic should certainly be given, the mucous membrane of the fauces snipped through, and the tonsil shelled out with the finger. The immediate hæmorrhage is not great, and usually stops quickly and spontaneously, especially if the patient does not use the voice or take irritating food soon after. If it threatens to continue, the patient should lie down, remain silent, and suck ice or cocain and rhatany lozenges. It is rarely severe unless a sharp knife has been used to cut off the tonsils, or when an excessive amount has been removed, or the tonsils have been much inflamed. In particular it does not follow shelling out of the tonsil. Recurrent hæmorrhage may occur, especially in anæmic adults, who, to avoid it, should be advised to remain quiet and take only liquid or soft food for a day or two. For severe hæmorrhage, a ligature should be applied on the bleeding point, if possible, or the anterior and posterior pillars may be drawn together over a pledget of gauze which can be removed the next day. Profuse hæmorrhage must be controlled with the finger, or by a sponge on a holder, or by a pencil with its end wrapped round with lint. But neither procedure, nor ligature of the carotid, external or common, should ever be necessary. When adenoid vegetations are present, the tonsils and adenoids may be removed at the same time, or the tonsils may be removed at a previous operation, after which the adenoids, if not very marked, may shrink, but in our experience this shrinkage does not usually occur; we therefore invariably do both operations at the same sitting, with the patient under the influence of a general anæsthetic.

Ulceration of the fauces, palate, and tonsils may be septic, gangrenous, syphilitic, tuberculous, or malignant.

Septic ulceration, or ulcerated sore throat, is generally the result of debility, induced by overwork in a close atmosphere, and hence is frequent in workers in hospital wards, where it is known as hospital sore-throat. Change of air, a nourishing diet, quinine and port wine, with a gargle of chlorate of potash, will usually relieve it. It may assume a *gangrenous* form, when extensive sloughing may ensue, with glandular swellings in the neck, rigors, and other constitutional symptoms of blood-poisoning which often prove rapidly fatal. The ulcers must be carefully swabbed with pure carbolic acid, or perchloride of mercury (1 in 500) until the gangrene stops. Stimulants and fluid nourishment should be frequently administered, and quinine, perchloride of iron, or ammonia and bark, given internally. Tracheotomy, if the larynx becomes involved, may be necessary.

Syphilitic ulceration may be superficial or deep. The *superficial* ulcers are common in the early stages of syphilis, and may be accompanied by mucous tubercles. *Deep* ulcers, due to the breaking down of gummata, occur in the latter stages as irregular excavations with sharply cut edges and a sloughy base, but are unattended with induration. On healing they are often productive of much contraction (see *Pharyngeal Stenosis*).

Tuberculous ulceration may primarily attack the pharynx, but is more often secondary to tuberculous affections of the lungs or nose. It is seen most often in delicate children, and bears a general resemblance to syphilitic ulceration, from which it may be distinguished by the discovery of the tubercle bacillus in the discharge. Like the syphilitic, it may lead to extensive destruction of the parts. It should be painted with lactic acid, commencing with a ten per cent. solution, or dusted with a powder of iodoform and morphine, or of orthoform.

Maligant ulceration is due to the breaking down of epitheliomatous and sarcomatous growths. It may be known by the sinuous, everted, and indurated edges of the ulcer and other signs of malignancy.

Diphtheria of the fauces.—The fauces are by far the commonest site for the inoculation of the diphtheria organism, which reaches this situation from a previous case through the breath, by spoons and other feeding utensils, by kissing, and perhaps through contaminated milk or water. The disease commences by malaise, fever, a dusky swelling of the fauces, and an indurated enlargement of the glands below the angle of the jaw. Within a day or so of the onset there forms on the tonsil and adjacent pillars of the fauces, nearly always symmetrically, a white membrane composed of fibrin with cells caught in the meshes. The membrane is intimately adherent, so that it can be peeled off only with difficulty,

leaving a raw surface. The *diagnosis* is confirmed by inoculating a culture tube from the membrane and observing the development of the Klebs-Loeffler bacillus. Diphtheria has especially to be diagnosed from acute tonsilitis and from follicular tonsilitis. In acute tonsilitis the temperature is generally high ; in diphtheria it rarely exceeds 101°F. to 102°F. In tonsilitis the tonsils and fauces are more swollen, redder, and covered with ropy, non-adherent mucus. The organisms present are pyogenic cocci, and the glands below the jaw, if enlarged, are soft; whereas in diphtheria the enlarged glands are hard, harder than tuberculous, and as hard as syphilitic glands. Follicular tonsilitis attacks patients after puberty, consists in hard concretions in the tonsillar crypts, and only in recurrent attacks do the concretions bridge the interval between the crypts. Septic complications may follow.

A further account of diphtheria, as well as the treatment, is given under *Laryngeal Diphtheria*, p. 797.

Tumours of the tonsil.—*Papillomata* and *adenomata* are sometimes met with, the former usually as pedunculated warty growths, the latter as circumscribed, rounded, moveable tumours which readily shell out when an incision is made over them. *Sarcoma* and *epithelioma* occasionally occur in the tonsil. They grow rapidly, soon affect the lymphatic glands in the neck, and extend to surrounding parts. Unless detected and removed whilst they are quite small and localised to the tonsil, they are beyond the reach of surgery. Other tumours in this region are rare.

Sarcoma occurs especially in women after thirty years of age, and causes a unilateral enlargement of the tonsil until it may appear of the size of a tangerine orange without ulceration, and with a soft, not marked, enlargement of the cervical glands. It is removed by cutting through the mucous membrane with scissors or with the cautery and then shelling out the tumour with the finger, hæmorrhage being checked by sponge pressure. The glands in the neck may be subsequently excised.

Epithelioma especially occurs in men over fifty years of age. It forms an indurated ulcer, rapidly followed by the appearance of hard shotty glands, below the jaw. In a few cases it has been found possible to remove the disease by excising the tonsil. Generally, however, a deep and dangerous operation in the neck is required, on the lines of that for removing the base of the tongue, the blood-vessels being drawn aside. If these are found to be implicated, the operation should be stopped. A communication with the pharynx is left after removal, through which a tube may be passed into the œsophagus and packed round with iodoform gauze, the patient being subsequently fed through the tube.

DISEASES OF THE GUMS.

Hypertrophy of the gums has been observed as a congenital affection, and may be met with where there is overcrowding of the teeth as a lobulated fringe-like growth of the gums, which, in severe cases, may so surround the teeth that they appear as if buried in it. The hypertrophied portion should be shaved off, and one or more of the teeth extracted.

Polypi of the gums, as they are called, are merely overgrowths of the little tongue of gum between the teeth, and appear generally to depend on the presence of tartar or caries. The offending tooth should be scaled, stopped, or extracted, and the growth cut off.

Papillomata, or warty growths, occasionally occur on the gums. They are generally pedunculated, and can be readily snipped off with scissors.

Spongy gums may occur as the result of scurvy or the abuse of mercury, and are sometimes met with in delicate, ill-fed children. The condition is often associated with superficial ulceration. The *treatment* consists in the removal of the cause, the use of an astringent mouth wash, proper regulation of the diet, and the constitutional remedies appropriate to scurvy.

Epulis.—This term, though formerly employed to signify any tumour growing upon the gums, is now usually restricted to the variety that was then distinguished as the fibrous or common epulis. An epulis consists principally of fibrous tissue, but may sometimes contain a few myeloid cells. It frequently appears to depend upon the irritation of a carious stump, and springs from the periodontal membrane lining an alveolus. Beginning as a swelling of the little tongue-like process of gum between the teeth, as it increases in size it appears as a hard, fleshy, circumscribed, smooth, or slightly lobulated elastic growth, covered by mucous membrane. When it has existed some time ulceration of the surface may occur, and one or more teeth become loosened or fall out. *Treatment.*—It should be excised with bone-forceps or a small saw, care being taken to cut away a small piece of the bone beneath, as otherwise it is apt to return. When quite small it may be shaved off, a thin layer of bone at its base gouged away, and the offending tooth or teeth removed.

Myeloid sarcoma (*myeloid epulis*) is occasionally met with on the gums as a rapidly-growing vascular tumour of a purplish-red colour and soft, spongy consistency. It should be very freely removed with the underlying bone, as otherwise it will return. The hæmorrhage during removal is generally free, and may require the actual cautery to restrain it.

Epithelioma (*malignant epulis*) of the gums is rare. In the upper jaw it has a marked tendency to creep up into the antrum

(*creeping epithelioma*) and to simulate caries or necrosis of the jaw. The portion of the jaw involved should be freely removed. If the antrum is invaded the superior maxilla should be excised.

DISEASES OF THE TEETH.

Diseases of the teeth, by preventing proper mastication, are a cause of ill health and defective growth in the young, and of dyspepsia and other disorders of the stomach in the adult. Defective teeth, moreover, are in themselves a channel for septic absorption, and by the decomposition in and around their cavities, are a source of stomatitis and buccal ulceration. The septic absorption may be purely localised to the gums and jaw, or extend to the glands of the neck, or may become generalised, and endanger life either by septicæmia, pyæmia (joint-suppuration), or by a slow form of septic anæmia termed pernicious.

Dental caries, as seen in non-erupted and imperfectly erupted teeth, arises partly from a defective enamel, and partly from decomposition originating in the mouth. The defect in the enamel may be hereditary or due to some early impairment of health, or the enamel is destroyed by organisms which become closely adherent to it. This destruction goes on rapidly in young people, especially in the lower teeth of those who, owing to nasal obstruction, breathe through the mouth.

Prevention of caries in the young is therefore a most important question; children must be taught to use a tooth-brush with soap, especially at night after the last meal, and to occasionally dislodge *debris* by drawing a floss silk ligature between the teeth.

The teeth also require attention with regard to overcrowding, and bicuspids may sometimes have to be sacrificed. In addition, carious temporary teeth, also the first permanent molar, which often become carious very early, if not extracted, give rise to spongy and bleeding gums, discharging alveolar abscesses termed gumboils, necrosis of the jaw, inflammation, tuberculous ulcerations in the mouth, and suppuration of the glands in the neck. Such teeth must either be temporarily filled or extracted, not left to be a source of foul infection.

Toothache.—When the caries has advanced sufficiently the nerve becomes exposed in the dentine or pulp cavity, and hot and cold water, sugar, and salt, irritate and give rise to pain. The cavity should be gently rinsed with warm water, dried, and then a small pledget of wool should be squeezed out of clove oil or pure carbolic acid, and inserted. Toothache is often set up by cold, and then quinine or salicylate of soda in full doses, also phenacetin, gives relief, whilst the gums may be painted with iodine and aconite tincture. Anæmia, malaria, and syphilis also give rise to it.

Trigeminal neuralgia, as the result of dental caries, has already been described (p. 449).

Eruption of Teeth.—The teeth are erupted normally as follows:—

TEMPORARY TEETH.		PERMANENT TEETH.	
Lower central incisors	7 months.	First molar	6 years.
Upper „ „	9 „	Lower central incisor	7 „
Lateral incisors	12 „	Upper „ „	8 „
First molars	14 „	Lateral incisors	9 „
Canines	18 „	First bicuspids	10 „
Second molars	24 „	Second „	11 „
		Canines, 2nd molar	12 „
		„ 3rd molar	18-24 „

Whilst precocity in eruption is congenital (a child may be born showing incisors) delayed eruption is particularly seen in rickets, and also in cretinism.

Teething.—Eruption of the temporary teeth often causes considerable reflex disturbance—so much so indeed that in some instances tetany or convulsions or epileptic fits may ensue; or the gums become sore and inflamed, decomposition goes on in the mouth, the food is badly masticated and improperly mixed with saliva. Gastro-intestinal catarrh is thus induced, from which the patient may die. If the gums are much swollen, an incision should be made into the gum on the outer side by a gum lancet or guarded bistoury, and the gums afterwards painted with borax and honey.

Eruption of the Wisdom Tooth.—The only tooth to give trouble in eruption among the permanent set is the third lower molar, or wisdom tooth. Severe pain may be felt, and the mouth held more or less spasmodically closed. The pain is often referred to the ear and down the throat and neck, owing to the reflex irritation of the inferior dental nerve. The tooth may be still buried in the gum, or have appeared through the gum in an oblique or horizontal direction, so as to become fixed beneath the second molar, in which it may gradually form a cavity sufficient to expose the pulp and set up toothache in that tooth. A skiagram will show the position of a tooth in any particular case. The tooth may be extracted under an anæsthetic, or, if it has not grown too much in a horizontal direction, the removal of a tooth in front may prevent overcrowding and afford relief from pain.

Supernumerary teeth.—When a tooth is missing and has not been extracted, an *x* ray examination may discover it buried in the jaw. But even when the teeth are of the normal number of thirty-two, supernumerary teeth may be found, especially in the regions of the incisors and canines of the upper jaw, less often in the lower jaw near the symphysis. Supernumerary teeth, moreover, may be found in connection with hare lip and cleft palate, and exceptionally in

the lines of the fœtal clefts of the face and neck, in the nose, or even in the lower eyelid, and in the line of the hyo-mandibular cleft. In connection with such supernumerary teeth, cysts may sometimes form, the tooth being found within the cyst.

Extraction of teeth.—No local anæsthesia is of any value;

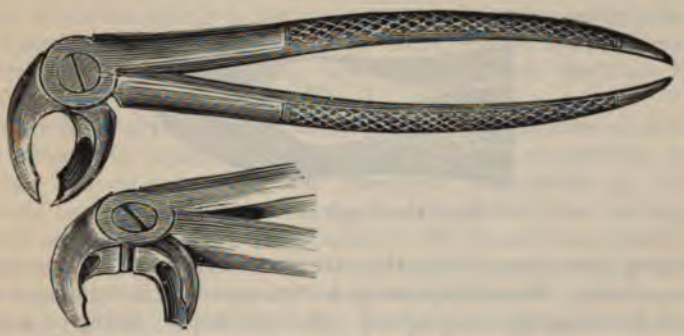


Fig. 362.—Lower hawk's-bill molar forceps.

for nitrous oxide gas administration see p. 230. The surgeon may stand to the right of the patient and use the right hand only, or

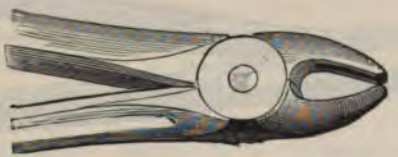


Fig. 363.—Upper straight root forceps.

stand in front, or to the side, and use either hand. The forceps (Fig. 362) are held with the thumb just between the handles to keep them apart, whilst the blades are firmly pressed down between

Fig. 364.—Dental elevator.

the gum and the tooth until well over the crown; then without a check lateral movements are made, first outwards and then inwards to break the alveolus and loosen the tooth, and the tooth is quickly pulled away. Conical teeth, such as the upper central incisors and canines, are rotated (Fig. 363); meanwhile the other hand must

support the jaw, to resist any tendency to dislocation. Stump roots are extracted by forceps the blades of which (see Fig meet, being pushed down over the edge until the root can be gr Elevators (Fig. 364) are sometimes required to loosen a ver tooth, also to lever out stumps. They must not slip so as to the tongue. If there is a difficulty, stumps may be left to u

Fig. 365.—Upper molar forceps.

atrophy from disuse, when they tend to be extruded or can be got out. Hæmorrhage rarely occurs, especially if the gum used for biting for a day or two. It is checked by biting on and fixing the jaw with a chin bandage, or by a small strip of io gauze packed in firmly. Rarely will perchloride of iron be re When used, lint should be soaked in it and then dried

Fig. 366.—Lower hawk's-bill root forceps.

insertion. Hæmorrhage from a tooth socket is only danger the case of hæmophilia (see p. 222).

Alveolar abscess may form around the fang of a carious and then either make its way to the surface by the side tooth, when it is quite superficial and is called a gum-boil, or the alveolus and perforate the bone. In the latter case i track below the reflection of the mucous membrane from th to the cheek, and point about the angle of the jaw or on the and after opening leave an intractable sinus. In the upp it sometimes also tracks along the hard palate, and may partial or extensive necrosis of the jaw, or it may extend i antrum, giving rise to empyema (see p. 789). It is attend severe throbbing pain, deep-seated swelling, and often great of the face and eyelid. An occasional and very dangerous c tion is septic phlebitis, which may be known by a brawny

of the cheek, with marked signs of septic absorption. Septic thrombosis of the cavernous sinus or some other pyæmic condition may then bring about a fatal termination. *Treatment.*—When quite superficial a mere prick is all that is generally necessary. The offending tooth should be extracted, hot fomentations and bread poultices applied inside the mouth, and the sinus divided transversely from within the mouth to prevent an external opening being formed. If a sinus exists the carious tooth or dead bone must be removed before it will heal; scraping the sinus will then facilitate the healing.

Pyorrhœa alveolaris, or Rigg's disease.—A number of alveoli are affected by septic suppuration, the teeth are covered with foul tartar, and on pressing on the gums pus is squeezed up. The mouth has a very foul odour, the patient suffers from prolonged septic intoxication, and in some cases Dr. W. Hunter has traced the origin of pernicious anæmia to this cause. *Treatment.*—The teeth are carefully scaled or scraped free from tartar, the pockets containing pus are wiped out with pledgets of cotton-wool and an antiseptic, and the gums are gently massaged with the finger to make them less œdematous and to squeeze out the pus from around the teeth. With the arrest of the septic intoxication the patient's general health will slowly improve.

Odontomata, or tumours composed of dental tissue, are classed by Bland Sutton as follows:—

Epithelial odontomes arise from the enamel organ forming multilocular cystic tumours in the lower jaw.

Follicular odontomes arise from the tooth follicle forming the dentigerous cysts (Fig. 367, p. 766).

Fibrous odontomes are formed by a thickening of the tooth sac so that the tooth is never erupted, but is imbedded in the centre of a laminated fibrous tumour, but the tooth may be small and ill developed, and the tumour then appears as a central fibrous mass. These tumours have mostly occurred in rickety children.

Cementomes are formed in a similar way; the thickened tooth follicle ossifies and the tooth becomes embedded in a mass of cementum.

Compound follicular odontomes arise from the irregular ossification of the capsule and the formation of the cementum in small fragments or ill-shaped bits of cementum and dentine, forming irregular teeth or denticles. Rare in man, they are more common in animals. The teeth not being erupted are noticed to be absent.

Radicular odontomes consist of dentine internally and cementum growing from the roots below the crown.

Composite odontomes form irregular ivory exostoses occupying the alveolar border of the lower jaw, in the upper jaw invading the nose or antrum. They are composed of all the elements of a tooth

constitutional symptoms of blood-poisoning which rapidly fatal. The ulcers must be carefully swabb carbolic acid, or perchloride of mercury (1 in 5(gangrene stops. Stimulants and fluid nourishme frequently administered, and quinine, perchloride ammonia and bark, given internally. Tracheotomy, becomes involved, may be necessary.

Syphilitic ulceration may be superficial or deep. T ulcers are common in the early stages of syphilis, accompanied by mucous tubercles. *Deep* ulcers, due t down of gummata, occur in the latter stages as irregul with sharply cut edges and a sloughy base, but are un induration. On healing they are often producti contraction (see *Pharyngeal Stenosis*).

Tuberculous ulceration may primarily attack the p more often secondary to tuberculous affections of the It is seen most often in delicate children, and bears a blance to syphilitic ulceration, from which it may be by the discovery of the tubercle bacillus in the dis the syphilitic, it may lead to extensive destruction of should be painted with lactic acid, commencing with a solution, or dusted with a powder of iodoform and n orthoform.

Maligant ulceration is due to the breaking down matous and sarcomatous growths. It may be k sinuous, everted, and indurated edges of the ulcer a of malignancy.

Diphtheria of the fauces.—The fauces are by monest site for the inoculation of the diphtheria or

be ventilated and the workpeople should change their working dress and wash their hands before going to meals, which should never be taken at the works. The teeth of workers must be inspected periodically and stoppings inserted. A patient shown to be susceptible returns to the works after recovery at a great risk of relapse.

Treatment.—As soon as the bone is found to have begun to necrose, it should be removed subperiosteally without waiting for it to become loose. The wound is then dressed with iodoform and gauze, and the result is rapid recovery, with the reproduction of the free border in the case of the lower jaw owing to the periosteum not having been much damaged. By this means the dangerous complications—fœtor, leading to septic pneumonia, sinuses and septic exhaustion, septicæmia, and death—are avoided.

Tumours of the upper jaw may be cystic or solid, and the latter innocent or malignant; whilst cysts may likewise occur in the malignant solid tumours.

Cystic tumours may be produced—1. In connection with the fang of a carious tooth. 2. By an error in development of the enamel sac covering the crown of the tooth (*dentigerous cysts*); and 3. By obstruction of a mucous follicle in, or myxomatous degeneration of, the lining membrane of the antrum. These cysts usually contain a serous, gelatinous, or a brownish fluid in which cholesterine is often found. The condition known as *dropsy of the antrum*, and formerly believed to depend merely upon an accumulation of fluid in that cavity owing to the occlusion of the opening into the nose, would appear to be due to one of these mucous cysts so distended as to completely fill the antrum.

Dentigerous cysts, or follicular odontomes, which may also occur in the lower jaw, are due to an error in the development of the tooth follicle, usually of the permanent teeth (Fig. 367). They differ from the ordinary dental cyst, depending upon the irritation of a decayed fang, in that in the latter the fang will generally be found projecting into the cyst, whereas in the dentigerous variety, the crown alone, which has not been cut, or in some cases the whole tooth, will be found in the cyst, the wall of which is formed by the dilated tooth-follicle.

Solid tumours may spring from the periosteum covering the exterior of the bone, from the cancellous spaces of the bone, or from the mucous or the periosteal lining of the antrum. They may have a fibrous, cartilaginous, osseous, myxomatous, sarcomatous or carcinomatous structure; but carcinomata and then myeloid and fibro-sarcomata are the most common, whilst chondrification or ossification of the sarcomatous growths is of occasional occurrence. They may be closely simulated by tumours of a like diversity of structure growing from the malar bone, the spheno-maxillary fossa, or the base of the skull.

arises from the spheno-maxillary fossa or base of the skull, it will commonly project into the naso-pharynx, where it may be detected by the finger or rhinoscope, while the whole maxillary bone will be pushed forward. It should not be forgotten, however, that tumours beginning in the antrum, especially the fibro-sarcomatous and carcinomatous, encroach upon the surrounding parts, and conversely, that the cavity of the antrum may be invaded by growths not primarily connected with it; so that when a tumour in this region has attained a large size it may be impossible to determine its origin, or, indeed, the extent of its actual attachments.

Treatment.—For *unilocular* cystic tumours, excision of a portion of the wall from within the mouth, by retracting the upper lip, will generally suffice, if a free drain is subsequently ensured. At times the thinned walls of the cyst may be crushed together by the fingers with advantage. The offending tooth should of course be removed. When the tumour is *solid*, and of an *innocent* nature, or a *myeloid sarcoma*, and entirely confined to the antrum, it should be enucleated, but if it has extended beyond the boundaries of that cavity it may be removed by excision of part of the superior maxilla, but as a rule no more of the bone should be taken away than is absolutely necessary, the orbital plate and hard palate, and even the alveolar border, being preserved if possible. When the tumour arises behind the bone, there is often great difficulty in getting it away, as its attachments may be more extensive than is imagined. This may be done by partly or wholly excising the superior maxilla, and clearing away the growth; or the maxilla may be turned outwards, the growth removed, and the bone replaced (*Langenbeck's method*).

When the growth is *maligant*—a *carcinoma* or *periosteal sarcoma*—and is confined to the antrum, the superior maxilla should be excised; but when it has invaded the surrounding parts, it becomes not only a question whether it can be completely got away, but whether the immunity from its return will not be of too short duration for the patient to undergo the risk of the operation.

Complete excision of the upper jaw.—The patient should have his head and shoulders well raised, and should be only kept lightly anæsthetised after the raising of the cheek flap. Having extracted the central incisor tooth on the diseased side, make an incision (Ferguson's) down to the bone in the direction shown by the dark line in Fig. 368. Raise and retract outwards the flap thus marked out from the bone, securing the larger arteries as they are divided. Make a longitudinal incision through the mucous membrane, lining respectively the floor of the nose and roof of the mouth, as far back as the soft palate, and then a transverse one along the junction of the soft with the hard palate on the diseased side. Now pass one blade of the long jaw-forceps into the mouth and the

other into the nose, and divide the alveolar process and hard palate; cut through the nasal process of the superior maxilla, and then through the malar bone, carrying the points of the forceps into the spheno-maxillary fissure. Seize the bone with lion-forceps, and wrench it away from its remaining attachments. The cavity should be immediately plugged by the assistant with a strip of iodoform gauze, and when the first gush of blood has ceased and the throat has been well cleared of blood, the strip should be withdrawn and the internal maxillary or any other large branch of that artery tied, and hæmorrhage from smaller vessels restrained by re-plugging the wound with strips of iodoform gauze. When the bleeding has been checked, any growth that may remain should be cut away or destroyed with the actual cautery. Unite the edges of the wound with horsehair sutures and the lip with hare-lip pins, and seal the skin incision with collodion. The plug may be removed after twenty-four hours, the cavity insufflated with iodoform and lightly re-plugged. Healing occurs readily and with little deformity. An obturator with false teeth should subsequently be fitted to the mouth.

Fig. 368.—Lines of incision for removal of upper and lower jaw.

Partial excision of the upper jaw usually consists in leaving the orbital plate, and is done by dividing with a key-hole saw the front wall of the antrum along the margin of the orbit, and completing the operation as above described.

Resection of the upper jaw (*Langenbeck's operation*) consists in turning the maxillary bone outwards so as to get at a tumour

Fig. 369.—Jaw saw, with moveable back.

behind it, such as a large naso-pharyngeal polypus, and then replacing the bone. As the connections of the bone along its outer part are left intact, its vascular supply is not completely cut off, and it soon forms fresh adhesions when placed back in position.

Tumours of the lower jaw, like those of the upper, may be cystic or solid, innocent or malignant. *Cystic tumours*, as in the upper jaw, may be developed in connection with an uncut tooth (*dentigerous cysts*), or around the fang of a decayed tooth. They are then unilocular. *Multilocular cystic tumours* have a marked

arises from the spheno-maxillary fossa or base of the skull, it will commonly project into the naso-pharynx, where it may be detected by the finger or rhinoscope, while the whole maxillary bone will be pushed forward. It should not be forgotten, however, that tumours beginning in the antrum, especially the fibro-sarcomatous and carcinomatous, encroach upon the surrounding parts, and conversely, that the cavity of the antrum may be invaded by growths not primarily connected with it; so that when a tumour in this region has attained a large size it may be impossible to determine its origin, or, indeed, the extent of its actual attachments.

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other into the nose, and divide the alveolar process and hard palate; cut through the nasal process of the superior maxilla and then through the malar bone, carrying the points of the forceps into the spheno-maxillary fissure. Seize the bone with bone-forceps and wrench it away from its remaining attachments. The cavity should be immediately plugged by the assistant with a strip of iodoform gauze, and when the first gush of blood has ceased and the throat has been well cleared of blood, the strip should be withdrawn and the internal maxillary or any other large branch of that artery tied, and hæmorrhage from smaller vessels restrained by re-plugging the wound with strips of iodoform gauze. When the bleeding has been arrested any growth that may remain should be cut away or destroyed with the actual cautery. Close the edges of the wound with horsehair sutures and the lip with hare-lip pins, and seal the external incision with collodion. The pins may be removed after twenty-four hours, the cavity irrigated with iodoform and lightly repacked. Healing occurs readily and with little deformity. An obturator with false teeth should subsequently be fitted to the mouth.

—Line of incision for removal of upper jaw

Partial excision of the upper jaw may be performed by leaving the orbital plate and a portion of the malar bone, and removing the front wall of the antrum along the line of the nose and completing the operation as above described.

Resection of the upper jaw [illegible] in which the [illegible]

[illegible]

[illegible] be a useful [illegible] replacing the [illegible] part are left intact to [illegible] it has [illegible]

Tumours of the upper jaw [illegible] upper jaw may be [illegible] upper jaw may be [illegible] destroyed [illegible] are the [illegible]

V.

predilection for the lower jaw. They are due to invasion of the jaw by epithelium derived from the enamel germ or dental groove. Some have been considered endotheliomata of the gum. The epithelial masses undergo degeneration, leading to cysts often of considerable size, so that the growth on section has a honeycomb-like appearance. These tumours grow very slowly, and may gradually destroy the whole bone, reducing it to a mere shell, but if completely removed do not recur locally. They do not affect the glands till quite late. The *solid tumours* are osteomata, central myeloid sarcomata, and periosteal sarcomata. The *osseous* tumours usually take the form of exostoses, and are not uncommon about the angle of the jaw. *Multiple osteomata* may also occur as part of the general affection *leontiasis ossea*. *Myeloid sarcomata* begin in the interior of the bone, grow slowly and expand the bone until it becomes so thinned that it may give a crackling sensation when touched. The tumour may then soften and become cystic or extend outwards to the neighbouring soft parts. It is recognised when cut into by the broken-down blood-clot, by the maroon colour of the growth and by being enclosed in a bony and fibrous capsule. *Periosteal sarcomata* spring from the periosteum, covering either the outer or the buccal aspect of the jaw, and may be of the spindle or round-celled variety. They grow as quickly in three months as do the myeloid in twelve, and rapidly involve the muscles, skin and lymphatic glands and become disseminated through internal organs. They have no capsule. The more regular shape of the lower jaw, its compact structure, the absence of a cavity like the antrum, its more isolated condition, and the absence of surrounding cavities like the nose, orbit, and spheno-maxillary fossa, make the diagnosis of tumours in it more easy.

Treatment.—The *unilocular cysts* are best treated by free incision, removal of the tooth, scraping out the interior, and crushing in their walls and filling the rest of the cavity with gauze. The gauze should be changed until healing by granulation has taken place. *Bony growths* should be excised if they press upon nerves and cause pain. *Myeloid sarcomata* should if possible be enucleated by scooping out the cavity through an incision within the mouth, or through the skin, along the line of the jaw. The wall of the cavity may then be scraped or gouged away, or the cautery applied and the cavity itself plugged with gauze. If the whole thickness of the ramus is involved a section of the jaw should be removed by cutting it across well beyond the growth on either side with a jaw-saw or with bone-forceps, but if possible a bridge of bone should be preserved to avoid deformity. *Multilocular epithelial cystic tumours* should be completely excised, a bar of bone, as in the previous case, being preserved if possible. In all the foregoing cases, provided the disease is completely removed, a permanent cure may be confidently anticipated. The *periosteal sarcoma* requires the removal of the

affected half of the lower jaw together with the neighbouring muscular tissue and the corresponding lymphatic glands, even where no infiltration is apparent. The prognosis is unfavourable, recurrence *in situ* or dissemination in internal organs being common. When a malignant growth is of very large size, the skin and neighbouring soft parts are implicated and the glands extensively involved, no operation, as a rule, is admissible.

Excision of one half of the lower jaw.—Having extracted the central or the lateral incisor tooth, make an incision down to the bone (in the way shown in the black line in Fig. 368) through the lower lip, along the lower border of the jaw, and thence up the ramus, nearly but not quite to the lobule of the ear to avoid the facial nerve, tying both ends of the facial artery as it is cut. Raise the flap thus formed from the bone with the masseter muscle, and divide the bone with saw and forceps opposite to where the tooth has been extracted. Seize the bone with the lion-forceps, drawing it outwards and upwards, and divide the mucous membrane and mylohyoid muscle on the inner surface with a narrow-bladed scalpel, keeping close to the bone to avoid the gustatory nerve and the sub-maxillary gland. The origin of the genio-hyoglossus should be spared if possible by dividing the bone a little to the side of the middle line, as otherwise the tongue tends to fall backwards, and has before now caused suffocation. If this muscle must be divided, pull the tongue forward by a ligature through its tip. Also if the digastric is spared, the jaw will not be drawn over so much to the opposite side. Next separate the internal pterygoid, and depress the jaw, and divide the temporal muscle at its insertion into the coronoid process. Open the articulation from the front, divide the external pterygoid, and carry the knife beyond the condyle, taking care not to rotate the jaw outwards, lest the internal maxillary artery be stretched around the neck of the condyle and be thus torn or divided.

Partial excision of the lower jaw.—Excision of the horizontal ramus or of the angle of the jaw may be required when the bone is involved by cancer of the tongue or by a central sarcoma which has extended beyond the bone. An incision is made along the lower border of the jaw, according to the extent of the tumour, and the cheek is raised until the buccal pouch is entered external to the teeth; if the facial artery and vein are divided both ends are tied. The jaw is cut across vertically by a jaw-saw or bone-forceps, and the tumour being drawn outwards it is then cut away from the mucous membrane and mylohyoid muscle. If a cast of the teeth is taken beforehand, a dental surgeon may be able to fit in a metal spanner which will keep the divided ends of the jaw apart until after healing, when a denture may be fitted. Otherwise the divided ends are drawn together by scar tissue so that the chin is displaced to that side and an ugly deformity

results. If the symphysis is excised the tongue must be kept from falling back.

Diseases of the temporo-maxillary joint.—*Deformity.*—In connection with an impaired development of Meckel's cartilage, the vertical ramus of the jaw and its articular process, and the external and middle ear, may be much arrested in development. The side of the face is flattened, and the chin deviated to the opposite side.

Arthritis.—When *acute*, this is generally septic in origin, especially when following purulent otitis media after scarlet fever, the inflammation then spreading to the joint by way of the tympanic artery, which runs through the Glasserian fissure. *Subacute arthritis* is generally rheumatic, fibrous adhesions tending to form. The *chronic arthritis deformans* affecting the joint may be rheumatoid or ataxic in origin.

Closure of the jaw, or stiff jaw, is a condition in which the movements of the jaw are much limited, or the teeth can be scarcely separated at all, thus causing great difficulty in taking food and in speech. An affection of the joint on one side effectually hinders movement of the opposite side.

(1) *Spasmodic closure* is due to spasm chiefly of the masseter muscle. The functional or hysterical variety may occur from emotional disturbance in women, and has been seen as an occupation spasm in public speakers, like writers' cramp, stammering, etc. Reflex spasm is very common in connection with the irregular eruption of the third lower molar, or wisdom tooth, much less common in connection with the second or first. The spasm is reflected through the sensory branches of the fifth nerve to its motor root, and thence to the masseter; or it may be due to cerebral irritation, as seen in tetanus. Local inflammation, such as mumps and parotitis, prevent the mouth from being opened owing to pain.

(2) *Intrinsic ankylosis*, or adhesions between the joint surfaces, is the result of traumatic inflammation, such as may be caused by pressure of the forceps at birth, by fracture, subluxation or dislocation of the jaw, by rheumatic inflammation or suppuration, or by arthritis deformans of the temporo-maxillary joint.

(3) *Extrinsic ankylosis* is the result of destructive inflammation of the soft parts, with or without necrosis of the jaw, such as burns, sloughing after fevers, cancrum oris, phosphorous necrosis, mercurialism, syphilis, lupus. Bands of scar tissue form in the skin, mucous membrane, and muscles, preventing movement of the jaw.

Treatment of stiff jaw.—In functional cases an attempt should be made to prevent incipient closure by free passive movements and by encouraging active movements, whilst ointments of mercury, belladonna, or sulphur may be employed. A rubber block may be wedged between the teeth and the chin drawn up with a bandage, after making an examination under an anæsthetic, or this contrivance may be worn at night if the jaw is liable to be stiff in the morning.

Forced opening in some cases may be effected by a screw gag. It is useless to employ much force, for the case will probably relapse and require a cutting operation. Care must be taken of the teeth, and it must be remembered that the jaw may be very fragile owing to atrophy from disuse. It is very seldom that any good can come of an attempted division of adhesions by a tenotome. For intrinsic ankylosis the condyle may be excised through a horizontal incision over the joint, or if a vertical incision is preferred, it must only be through the skin, and then the masseter, facial nerve, and parotid duct should be hooked downwards. It is often very difficult to cut out an ankylosed condyle, and the base of the skull has been fractured in the attempt. A chisel or gouge should be used, holes being drilled first. The internal maxillary behind the neck must be avoided or there will be troublesome hæmorrhage, which may not cease until the external carotid is tied. The result is good if healing occurs by first intention and there is no extrinsic cause of ankylosis. Passive movement is begun as early as possible.

For *extrinsic ankylosis* the only satisfactory measure is a wedge-shaped excision of the angle of the jaw. This procedure is superior in its results to osteotomy or excision of the neck of the condylar process, division of cicatrices within or without the mouth, or detachment of the insertion of the masseter with forcible opening, for relapse is almost certain if these operations are done. The incision should pass round the angle, not extending more than half-way up the ascending ramus. The soft parts can be separated by raspatories, and a wedge with its apex at the alveolar border cut out with the bone-forceps or saw. After this operation, even in a severe case, the mouth may be opened for an inch and a half; passive and active movements are easily carried out, and there is no tendency to relapse. But some deformity remains in the movement of the masseter, and the patient cannot grind his food. A puckered and contracted scar left at the angle of the mouth may be improved by excision and skin-grafting.

DISEASES OF THE NOSE, NASO-PHARYNX, AND ACCESSORY CAVITIES.

Acne rosacea is a dilated or congested condition of the capillaries of the nose, usually accompanied in its later stages by hypertrophy of the sebaceous follicles. It is attributed to indigestion, exposure to cold, sexual disturbance, or the abuse of alcohol, and is most common in women. *Treatment.*—Remove the cause, regulate the diet, and attend to the general health. Locally apply sulphur ointment or perchloride of mercury lotions. In severe cases the dilated vessels may be scarified and the resulting hæmorrhage restrained by touching them with perchloride of iron, but only small portions of the disease should be thus treated at a time.

Rhinophyma or lipoma nasi is an hypertrophy of the skin,

subcutaneous tissue, and sebaceous follicles of the nose, and not, as the name implies, an increase in the fatty tissue. It is characterised by the formation of irregular pendulous lobe-like masses, usually situated on the tip and alæ of the nose, and often of a bluish-red colour. It occurs in elderly men, generally as the result of alcoholism. *Treatment.*—The masses should be shaved off, care being taken not to cut through the cartilages into the nostrils, and the parts left to granulate. The treatment is usually very successful.

Lupus, rodent ulcer and epithelioma may all attack the exterior of the nose, but require no special description here.

Gummata over the nasal bones are not uncommon. They present the characters of gummata in other situations, and give rise to boring nocturnal pains. The interior of the nose is generally affected at the same time.

Deformities resulting from lupus or syphilis may perhaps be

Fig. 370.—Duplay's nasal speculum.

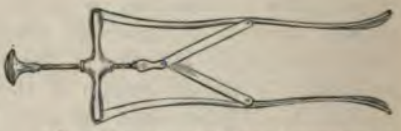

Fig. 371.—Fränkel's nasal speculum.

repaired by insertion of a celluloid plate, plastic operations, or paraffin injections (see *Rhinoplasty*, p. 497).

Examination of the nasal cavities.—For the diagnosis of internal diseases the nasal cavities should be illuminated by the laryngoscopic mirror or the electric lamp, the alæ being separated by some form of nasal speculum, of which Duplay's and Fränkel's are the best (Figs. 370, 371). The examination should be made systematically. It is not sufficient to merely introduce the speculum and look at the parts with the head in the position it happens to be at the time. The head should be thrown back to gain a view of the middle turbinal body and upper portion of the nasal chambers; then held straight to inspect the inferior turbinal body and corresponding part of the septum; next the chin should be depressed that the floor may be examined and the patency of the inferior meatus ascertained. Finally the head should be rotated to and from the light, the better to see the lateral boundaries of each nasal chamber. The posterior part of the nasal cavities can be explored by the finger passed behind the palate, or by a small mirror passed to the back of the throat (*posterior rhinoscopy*). For detecting necrosed bone the nasal probe may be used.

Epistaxis, or bleeding from the nose, is a symptom of many

and various conditions. Thus—1. In childhood it often appears to occur spontaneously from congestion of the mucous membrane, and is especially common in girls about the age of puberty. 2. In cerebral congestion it appears to give relief to the over-full vessels by the draining away of the blood by the emissary veins which run from the interior of the cranium to the nasal mucous membrane. 3. Severe epistaxis is not uncommon in patients likely to suffer from apoplexy, the bleeding being of service in relieving the excessive pulse tension connected with granular kidney, cirrhosis of the liver, and heart disease. 4. It may also occur in scurvy, the worst forms of the acute specific fevers, and in the hæmorrhagic diathesis. 5. It is common after blows or other injuries of the nose. 6. It may be a symptom of fracture at the base of the skull, of an angioma of the septum, of tuberculous ulceration, or of adenoid, fibrous, or malignant growths in the nose or naso-pharynx. 7. In many cases of recurrent epistaxis the bleeding appears to be of local origin, and occurs at a spot called the *seat of election* from an artery or vein on the anterior and lower end of the septum, just within the anterior nares. This spot may be recognised in the intervals between the bleeding by minute vessels radiating from it, and often by the presence of a dry crust covering a small ulcer. Every time the crust is disturbed or picked off a hæmorrhage is liable to occur. Dryness of the nose induced by anæmia, by hard coughing, or by plethora especially predispose to the formation of this ulcer, and hence to epistaxis. Every case of recurring epistaxis, therefore, should be examined by the speculum. The *symptoms* are usually evident. The blood generally comes from one nostril, occasionally from both; but it may pass through the posterior nares and be swallowed, and being afterwards vomited, simulate hæmatemesis; or it may irritate the larynx, cause cough, and may then be mistaken for hæmoptysis. On looking into the mouth in such cases, however, the blood will be seen trickling down the back of the throat; whilst it may also be apparent on examining the nose with a speculum, and may be seen flowing from a small vessel when it comes from the seat of election. The *treatment* will depend upon the cause. Spontaneous hæmorrhages occurring in childhood, except as the result of the hæmorrhagic diathesis, generally stop of their own accord, and require no special treatment beyond those remedies common in domestic use. When due to congestion and apparently salutary, the bleeding should not be too soon checked. When the bleeding occurs from the seat of election the application of boracic acid ointment and a nasal spray will often prevent a recurrence. If still bleeding, a pellet of cotton-wool soaked in cocain (20 per cent.) applied to the bleeding spot for five minutes will often stop it; if not, the galvano-cautery point or a probe heated in a spirit lamp will at once arrest the flow. Afterwards ointment should be used till the part has healed. In cachectic subjects it is often difficult to control the hæmorrhage,

and this is also sometimes the case in malignant growths and after certain operations and injuries. If rest on the back, ice to the nose, insufflations of antipyrin (10 per cent.), or tannogallic acid, hazeline locally and internally, subcutaneous injections of ergotin (gr. iij.), or a flake of wool soaked in adrenalin, do not arrest it, the nose should be plugged. The best method of effecting this is by the rubber tampon bag. The nose is first cocainised and the bag well smeared with glycerine, inserted and then inflated. It should be left *in situ* for twenty-four hours or longer. If the hæmorrhage is severe, the nose must be plugged more firmly by pushing in strips of iodoform gauze with nasal forceps against the index finger of the opposite hand in the naso-pharynx till the whole nose is filled. The end of the strip should be left out on the face and removed within twenty-four to forty-eight hours. The old method of plugging the posterior nares with Bellocq's sound (Fig. 372) is now seldom used. Plugging the anterior and posterior orifices only may be followed by the blood passing up the nasal duct to the conjunctiva.

Ozæna is a term which has been used very loosely by authors. By some it has been applied to all diseases of the nose attended with a foul-smelling discharge, whilst by others it has been restricted to the fœtid form of atrophic nasal catarrh. The term, therefore, as designating a disease, is misleading, and should be discontinued in this sense. For purposes of diagnosis it may be mentioned that it is a prominent symptom in the following affections of the nose—1, atrophic nasal catarrh; 2, necrosis and caries, whether of syphilitic or other origin; 3, tuberculous, lupous or syphilitic ulceration of the mucous membrane; 4, foreign bodies and rhinoliths in the nasal cavities; 5, purulent catarrh of the antrum or one of the other accessory sinuses; and 6, some forms of new growth.

Fig. 372.—Bellocq's sound.

Nasal catarrh, rhinitis, coryza, or inflammation of the mucous membrane of the nose, may be acute or chronic.

Acute catarrh, coryza, or *cold in the head*, will be found treated of in works on Medicine.

Chronic nasal catarrh or *rhinitis*, also known as *hypertrophic rhinitis*, is most common in the young, especially in children. As exciting causes may be mentioned oft-repeated attacks of acute catarrh, adenoid vegetations in the vault of the pharynx, enlarged tonsils, nasal stenosis, deflected septum. The *simplest* form is characterised by a thin mucous or muco-purulent discharge, and a congested appearance of the mucous membrane, but is unattended with any thickening. If neglected, the mucous membrane, especially over the turbinated bones, where it is greatly swollen and congested,

becomes hypertrophied and infiltrated with inflammatory material; while the glands are stimulated to excessive secretion, and pour out a muco-purulent discharge. It is characterised by symptoms of nasal obstruction—viz., stuffiness or blocking of the nose, nasal tone of voice, constant need to blow the nose, a vacant expression of countenance acquired by keeping the mouth open, trickling of the discharge down the pharynx and subsequent hawking of it up by coughing, and sometimes deafness from the spread of inflammation to the Eustachian tube. At times certain reflex phenomena are present, such as spasmodic cough and asthma. The alæ of the nose often appear excoriated and thickened, owing to the irritation of the discharge, or, when much obstruction exists, pinched. The inferior turbinated bodies are greatly enlarged. On posterior rhinoscopic examination granular pharyngitis is frequently discovered, with increase of the glandular tissue of the vault of the pharynx; whilst

FIG. 373. — Hypertrophic nasal catarrh. (St. Bartholomew's Hospital Museum.)

FIG. 374.—Hypertrophy of the posterior ends of the inferior turbinated bodies, with adenoid vegetations in the vault of the pharynx.

the hypertrophied posterior ends of the inferior turbinated bodies may at times be seen almost completely blocking up the choanæ in the form of globular, irregularly-furrowed tumours (*grubworm hypertrophy*) (Figs. 373, 374). Hypertrophic rhinitis is said by some, but without sufficient evidence, we think, to pass, after it has lasted some years, into the atrophic variety.

Atrophic rhinitis, sometimes called *dry* or *fœtid* catarrh, and by some wrongly termed *ozæna*, is apparently due to the shrinking of inflammatory new formation infiltrating the tissues, and the consequent atrophy of the mucous membrane and the greater or less destruction of the glands. It is generally due to anæmia, but may be made worse by noxious vapours or dust. It is characterised by the nasal cavities appearing preternaturally large, so much so that in some cases the wall of the pharynx and Eustachian tube may be seen on looking through the nostril. The turbinated bodies appear decreased in size, and the mucous membrane is atrophied and paler than natural and covered with hard yellowish-green adherent crusts.

Generally, though not invariably, the disease is attended with a horrible fœtor, which is due to the decomposition of the discharge beneath the crusts, the discharge being secreted in too small quantities and too thick to allow of the throwing-off of the crusts. In some cases the disease extends into some of the sinuses communicating with the nose. In all forms an important point to remember is that ulceration does not occur.

Treatment.—In the early stages much can be done in the way of treatment, and by perseverance a cure may be obtained. In the advanced atrophic variety relief from the distressing symptom of fœtor only can be expected. In both forms the general health must be attended to. Thus, cod-liver oil or maltine, and the syrup of the iodide or phosphate of iron, are indicated. Locally, in the

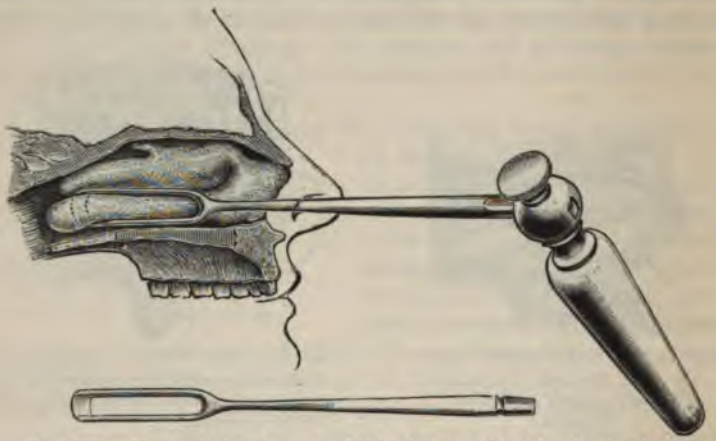

Fig. 375.—Removal of an hypertrophied inferior turbinal by the ring knife or spokeshave.

simple and milder forms of the hypertrophic, the treatment consists in cleansing the parts and then applying astringents; the cleansing may be accomplished by simply blowing the nose, or if this is not sufficient, a cleansing fluid must be used. There are many of these. One of the most useful is that known as Dobell's solution (sodæ bicarb., sodæ biborat., sodæ chlor. āā gr. ij., glycerine ʒj, carbolic acid gr. j., aquæ ʒj.), but peroxide of hydrogen is perhaps equally as good. The cleansing lotion should not be used, as is so frequently done, by Thudichum's nasal douche, as by its means the deeper recesses and upper portion of the nasal fossæ cannot be reached, and not only may much harm be done to the mucous membrane of the nose, but inflammation of the middle ear may be set up. The solution is best applied in the form of a coarse spray, either by the anterior or posterior nasal spray producer, but a common glass syringe may be used (Fig. 376). When thoroughly

cleansed, astringent or sedative solutions — best in the form of sprays — should be applied, and of these may be mentioned tannic acid, sulpho-carbolate and iodide of zinc, or menthol, eucalyptol (ʒss. to ʒj.), terebene (gr. xx. to ʒj.), cocain or thymol (gr. x. to ʒj.), dissolved in liquid petroleum, a better vehicle than water for intranasal medication. Astringents or iodoform may also be applied in the form of powders by the insufflator, or in the form of gelatine bougies. Where there is great hypertrophy, the hypertrophied tissues must be destroyed by the local application of chromic acid or the galvano-cautery; or the ends of the inferior turbinated body if much enlarged may be removed by Jarvis' cold wire snare, by the punch forceps, by the galvanic écraseur, or by the ring knife or spokeshave (Fig. 375). At times the whole of the turbinated body may be removed with advantage. If the septum is deflected, it must be straightened; and if adenoid growths are present, they must be removed. In the atrophic form little more can be done than cleansing and disinfecting the cavities by lotions of carbolic acid, borax, aristol (ʒss. to ʒj.), and the like; whilst the mucous membrane may be stimulated to secretion by the use of Gottstein's nasal tampons, or by the insufflation of sanguinaria, galanga, etc. Very adherent crusts are got rid of by putting up the nose boric acid ointment at night and washing out the nose by day with increasing strength of bicarbonate of soda lotion. Cubebs or senega internally is often of service.

FIG. 376. — Spray producer. A. Nozzle for anterior nares; B. nozzle for posterior nares.

Membranous or diphtheritic rhinitis occurs in two forms—one, acute, which is combined with the formation of membrane on the fauces, when the antitoxin treatment is most important, and the other chronic, which occurs in weakly children, and in which the membrane on the nose contains infectious bacilli, though in a relatively inactive state. Children thus affected should be isolated.

Turbinal erection, *i.e.*, transient and oft-recurring congestion of the turbinal bodies, is very common. The patient complains of intermittent attacks of obstruction to free nasal breathing, especially at night or on entering a hot room, and of an attending flow of a watery fluid from the nostrils. At times there is excessive sneezing. On examination the turbinals are seen enlarged, but the enlargement may be distinguished from hypertrophy by the turbinals dimpling when touched with a probe and becoming smaller when painted with cocain. Turbinal erection is a common symptom in the condition known as *Hay Fever*. Touching the turbinals in two or three places with the galvano-cautery will generally effect a cure, and even in hay fever often gives great relief. *Hay fever* and *asthma*, if not relieved by cauterisation of the turbinals, may

sometimes be much benefited by cauterisation of the septum, selecting specially irritable points.

Tuberculous ulceration sometimes occurs. It may lead to necrosis of the bone, falling-in of the nose, and much deformity. Constitutional remedies, as cod-liver oil, must be given, and the parts cleansed by lotions, applications of iodoform, lactic acid, etc. When obstinate, scraping the part with a Volkmann's spoon, and removal of the dead bone, is the treatment indicated; when limited to a turbinal bone, the turbinal should be removed; when limited to the septum, the nose should be laid open and the diseased part of the septum cut out.

Lupus, though far more common on the exterior of the nose, may sometimes be met with in the interior. It then generally

Fig. 377.—Cold wire écraseur, tightened by the thumb turning the milled head of the screw.

attacks the cartilage of the septum, leading to perforation. It is attended with a fœtid discharge. The lupous patch is covered with broad, flattened, brownish scales or crusts, and surrounded with reddish tubercles. On the removal of the crusts the ulcerated surface is found soft and friable. *Treatment.*—Cod-liver oil, arsenic, and the complete destruction of the affected tissue by caustics, lactic acid, or by scraping, is the proper treatment.

Syphilitic affections of the nose. In the early stages of syphilis, catarrhal inflammation and mucous tubercles are often met with, especially in infants, in whom they give rise to the obstructed and noisy respiration popularly known as "*snuffles.*" Later, extensive ulcerations, gummata followed by deep ulcers, necrosis or caries of the bones and cartilages, destruction of the septum with falling-in of the nose and perforation of the palate may occur, and when combined with destruction of the soft tissues and skin, are productive

of great deformity. When a small portion of bone in the deeper recesses is necrosed, it may not always be easy to find, but may be suspected by the continuance of a muco-purulent discharge and the fœtor so peculiar to dead bone, the presence of foul ulcers, the history or constitutional signs of syphilis, and the absence of signs of hypertrophic or atrophic catarrh. Often the bone may be struck on examination with the nasal probe. *Treatment.*—Iodide of potassium should be given in large doses, combined, if necessary, with quinine or bark, and at times with mercury. Locally the parts should be cleansed and disinfected by the application of carbolic or other sprays, and when dead bone can be detected it should be removed, if loose, through the anterior nares or from behind the palate by forceps; but sometimes it may be necessary for obtaining a sufficient exposure to resort to the method of Rouge, or to cut through the upper lip and turn aside the ala of the nose. In congenital syphilis the administration of small doses of grey powder, followed by iodide of potassium and cod-liver oil, is productive of the most happy results. In the ulcerative form, iodide of potassium in large doses should be given.

Rhinoliths or nose stones may occasionally form in the nose from the deposition of phosphate of lime and mucus upon either a foreign body which has become lodged in the nose, or a portion of hardened secretion. They give rise to inflammation, swelling of the mucous membrane, and a fœtid discharge, and have been mistaken for osteomata and even for carcinomata. When detected they should be removed by forceps, or if too large for this, first broken by the nasal lithotrite.

For the treatment of foreign bodies in the nose, see p. 500.

Polypi.—Three forms are described—the gelatinous, the fibrous, and the malignant.

1. *Gelatinous or mucous polypi* most frequently spring from the mucous membrane lining the middle meatus, often forming a cluster around the anterior end of the middle turbinal body, or from the ethmoid cells, and sometimes, but rarely, from the septum. They usually have a myxomatous structure—that is, they consist of delicate connective tissue (Fig. 378) infiltrated with large quantities of mucin containing round and stellate cells, and are covered with ciliated epithelium. They are usually multiple, sessile or pedunculated, and of an oval, pyriform, or lobulated shape. They are probably myxomatous tumours, as are other mucous polypi, and like other benign tumours, their cause is at present unknown. Some rhinologists hold that they are secondary to periostitis and necrosis of bone, "necrosing ethmoiditis," but the evidence, both clinical and microscopical, of such an affection being the cause seems to us quite insufficient. The usual *symptoms* are a feeling of stuffiness in one or both nostrils, worse in damp weather, a nasal tone of voice, and a mucous discharge. Certain reflex symptoms, such as asthma,

cough, etc., are also occasionally present. At times they are attended with partial or complete loss of smell (*anosmia*). On inspection, they appear as pinkish or greyish-white, semi-translucent, gelatinous, moveable bodies, soft and dimpling when touched with a probe. When high up, or far back in the nasal cavities, the speculum or rhinoscope may be necessary to detect them. With the rhinoscope we have often succeeded in detecting a polypus at the posterior nares that had been previously overlooked. When a polypus approaches the anterior nares it is liable through irritation as by the finger to become inflamed and granular, and of a pinkish colour or even black from hæmorrhage into its substance, and its

Fig. 378.—Mucous polypus. Photograph of a section of a mucous polypus. Normal epithelium covering a delicate connective tissue infiltrated with leucocytes and mucin.

gelatinous appearance being lost, it may then be mistaken for a sarcoma unless care is taken to examine its remoter and unirritated portions. Nasal polypi generally occur in adults and are not seen at all in children. They are sometimes associated with polypi in the antrum and frontal sinuses.

Diagnosis.—The two conditions most likely to be mistaken for a polypus are a deflected septum and enlarged turbinal. In a deflected septum the concavity may be seen on looking into the opposite nostril, and an enlarged turbinal is of a pinkish-red colour and attached to the outer wall of the nose. A naso-pharyngeal fibroma and a malignant growth might also be mistaken for a gelatinous polypus, but may be distinguished by the frequent hæmorrhages to which they give rise, by the naso-pharyngeal fibroma being felt

behind the palate; and by the fungating bluish-red appearance of the malignant growth. An encephalocele has protruded through the base of the skull in the region of the sella turcica, with or without a cleft palate. It would be seen in an infant or young child in which a mucous polypus does not occur, and would exhibit a cough impulse, if not also pulsation.

Treatment.—Gelatinous polypi are best removed by the galvano-cautery snare, as this is attended with less pain and with practically no hæmorrhage. The parts should be previously anæsthetised with a 20 per cent. solution of cocain applied on a pledget of cotton-wool, and after the removal of the polypi the surface from which they sprang should be touched with the galvano-cautery point to prevent a recurrence. If the cautery is not at hand, the polypi may be removed by the cold wire snare or be twisted off by the ordinary polypus forceps. When they project into the naso-pharynx, they may be removed, either with the galvano-cautery loop passed through the nose or by suitable forceps introduced behind the palate. A snuff of tannic acid, used subsequently to their removal, is said to prevent recurrence, but is not really of much service. When the polypi quickly recur they should be removed under an anæsthetic, together with the middle turbinal and the ethmoid cells curetted. The nose may be plugged if the hæmorrhage is severe. By this means the disease may be cured or its recurrence prevented for a long time.

2. *Fibrous and fibro-sarcomatous polypi* actually arising from the interior of the nasal cavities are rare. Those commonly met with usually spring from the basilar process of the occipital bone or body of the sphenoid, that is, from the roof of the naso-pharynx, and then ought properly to be called *naso-pharyngeal*, as it is only after they have attained some size that they encroach upon the nasal cavities. They consist of fibrous tissue not infrequently mixed with spindle cells, and often contain large thin-walled blood-vessels, which give them an almost cavernous structure (*fibro-angiomata*). The mucous membrane covering them is also very vascular. They may be sessile or broadly pedunculated. As they increase in size, they become more definitely fibro-sarcomatous, and invade and displace the surrounding bones, making their way into the nasal cavities or antrum, or into the pharynx projecting below the palate, or even into the interior of the skull. They are usually met with in young adult life. The *symptoms* are obstruction of one or both nostrils, a mucous and often foul-smelling discharge, repeated attacks of hæmorrhage, deafness, obstruction to breathing and sometimes to swallowing, and in the later periods of the growth the characteristic deformity of the facial bones known as *frog-face*. They may be seen on looking into the nostril from the front, or by the rhinoscopic mirror from the back, or may be felt by the finger behind the soft palate. If not removed, they may end fatally from

hæmorrhage. They have been said to show a tendency to undergo atrophy as the patient gets older, but there appears to be little or no evidence that this statement is founded on fact. *Treatment.*—The removal of these growths is attended with profuse hæmorrhage. It is safer therefore to fully expose them by a preliminary operation. If chiefly confined to the naso-pharynx, the soft palate should be split, and the two halves held aside by silk ligatures, whilst if more room is required part of the hard palate may be cut away after reflecting the muco-periosteum (*Nélaton's operation*). We have employed this method in several cases and found that it gives an excellent exposure of the growth. When encroaching chiefly on the nose, a good exposure may be obtained by dividing the lip in the middle line, and turning it to one side with the ala of the nose; or if more room is required, the superior maxilla may be partly or wholly removed. Rouge's operation of turning up the upper lip and the cartilaginous portion of the nose after division of the septum, and the operation of Langenbeck of turning the maxillary bone outwards on the cheek, and then replacing it after removal of the growth, have their advocates. Our experience of these last-mentioned procedures is not very favourable. The exposure obtained by the former is no better than that gained by turning back the ala; and the shock and hæmorrhage attending the latter render it very dangerous. Many other methods and modifications of the above have been proposed, but for an account of these a larger work on surgery must be consulted. Having well exposed the growth, it should be rapidly gouged away with the raspatory, or it may be removed with the écraseur or cutting forceps, and the base destroyed by the actual or galvano-cautery. The naso-pharynx may then be plugged with iodoform gauze, the ends of the strips being brought out through the nose, and removed through this passage after twenty-four hours. At the end of the operation the palate should be united, the lip sutured or the parts replaced, according to which method of exposure has been practised.

3. *Malignant polypi.*—Sarcomatous and cancerous tumours may arise both in the nasal cavities and naso-pharynx, and then constitute what are called malignant polypi. They give rise to symptoms similar to those of the fibrous polypi already described, but their growth is more rapid, and they quickly infiltrate surrounding parts and involve the neighbouring glands. They may occur both in the young and in the old. If a small piece can be removed, the microscope will reveal its nature. *Treatment.*—When the growth can be got completely away, early and free extirpation by one of the methods above described is the only treatment.

Diseases of the septum nasi.—*Hæmatomata or blood-tumours* are occasionally met with as the result of injury. The blood is extravasated between the cartilage and the soft tissues, generally on both sides of the septum, causing in both nostrils a fluctuating

circumscribed swelling which may be readily distinguished from abscess by its coming on immediately after the injury and by the absence of signs of inflammation. It should not be opened unless it suppurates, as the blood will become slowly absorbed. It sometimes appears to be associated with fracture of the septum.

Abscesses of the septum are not very common. They may be due to injury or the breaking down of a gumma or hæmatoma, but occasionally occur without any apparent cause. When acute they may lead to perforation of the septum. The parts are hot, red, and swollen, and fluctuation may soon be detected. A free and early incision should be made.

Gummata of the septum occasionally form beneath the perichondrium in the course of syphilis. They are readily dispersed with iodide of potassium, but if neglected ulceration ensues and may lead to necrosis and perforation of the septum and to destruction of the bones which may sometimes be so extensive as to cause falling in of the bridge of the nose. The ulcers are characteristic, being deeply excavated, foul, covered by greenish-black sloughs, and surrounded by a bright shining areola of inflammation.

Tubercle of the septum occurs in two forms—the *hyperplastic* and the *ulcerative*. In the former a small, readily bleeding, red swelling is seen; in the latter a shallow, yellowish-grey ulcer. Both forms are usually situated near the anterior part of the septum and are nearly always associated with tubercle in other parts of the respiratory tract. Removal by excision, scraping, or the application of lactic acid is the best local treatment.

Perforating ulcer of the septum.—A small ulcer at the seat of election (see *Epistaxis*), due neither to tubercle nor to syphilis, is sometimes met with near the anterior end of the septum just within the nostril. It runs a very chronic course, crusts form and are detached, and finally the cartilage necroses and perforates the septum, leaving a small circular aperture with smooth healthy margins.

Deflection of the septum to one or other side may occur as the result of an injury, or as a congenital malformation. It appears as a swelling projecting into and obstructing one of the nasal cavities, whilst in the other cavity a corresponding depression is seen. The inferior turbinal body on the side of the concavity is often much hypertrophied. The deflection is generally attended with some lateral deviation or even depression of the lateral cartilages, and frequently gives rise to chronic nasal catarrh, deafness, and to many distressing symptoms, such as frontal headache, nasal tone of voice, passage of mucus into the pharynx, etc. *Treatment.*—The septum may generally be forcibly straightened by the forceps shown in Fig. 379, and then retained in position for the first few days, while the parts are becoming consolidated, by the retentive apparatus shown in Fig. 380, and subsequently by ivory or

vulcanite plugs (Fig. 381). Walsham has found hollow plugs (Fig. 382), or short portions of rubber tubing, useful in that they do not so completely obstruct nasal respiration. In some instances portions of the prominent septum may be removed by the nasal

Fig. 379.—Walsham's forceps for straightening nasal septum.

Fig. 380.—Retentive apparatus for deflected septum.

saw with advantage. Where the lateral cartilages and nasal bones are deviated they can generally be straightened, even after many years have elapsed since the injury. Great force, however, is required, and care must be taken, by properly padding the forceps,

Fig. 381.—Nasal plugs.

Fig. 382.—Hollow nasal plugs.

not to injure the soft parts. When the cartilages are depressed something can be done to rectify the broadened and flattened nose by subcutaneous osteotomy and wiring of the cartilages. One of the best forms of retentive apparatus then is, perhaps, the mask

Fig. 383.—Walsham's nasal mask.

Fig. 384.—Walsham's fixation-cap and nasal truss.

shown in the accompanying diagram (Fig. 383), since by its means a fixed point is secured to work from. As the mask, however, is irksome to some patients Walsham has more recently, for suitable cases, employed the nasal cap and truss depicted in Fig. 384.

Tumours of the septum.—Fibrous, cartilaginous and osseous tumours, though rare, occasionally occur, and can be readily diagnosed from a deflection of the septum, by their hard and resisting nature and

the absence of a corresponding depression in the opposite nostril. Their removal is the proper treatment.

Angiomata, or *arterial nævi*, are not infrequent. They are attended with severe hæmorrhages, and bleed profusely if touched. Great care is therefore necessary in their removal, which should be done with the cold or galvano-cautery snare. *Sarcomata and carcinomata* are also met with as rapidly growing and readily bleeding tumours attended by frequent epistaxis. They should be freely exposed and cut away if not too extensive.

Adenoid vegetations in the vault of the pharynx are very common in childhood. They are produced by the hypertrophy of

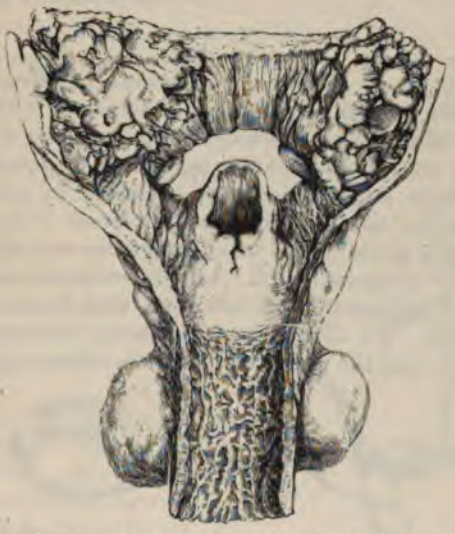

FIG. 385.—The naso-pharynx, pharynx and œsophagus opened from behind to show adenoid vegetations in the vault of the naso-pharynx. (St. Bartholomew's Hospital Museum, No. 1806 *c*.)

the adenoid tissue which is abundant in this situation, especially in the posterior wall of the pharynx, where it forms a mass known as the pharyngeal or *Luschka's tonsil*. They are frequently met with in connection with enlargement of the tonsils, granular pharyngitis, and nasal catarrh, and if neglected may set up otitis media and incurable deafness. The chief symptoms to which they give rise are deafness, obstruction to nasal respiration, snoring, a nasal or "dead" tone of voice, and a vacant expression of countenance from the child breathing with the mouth half open. To the finger behind the palate they feel soft, pulpy, and velvety, whilst in the mirror they appear as pink or reddish, sessile or pedunculated masses more or less obscuring the posterior nares (Figs. 374 and 385). *Prevention.*—This involves the proper care of children,

especially the avoidance of cold and damp. The child should be induced to breathe through the nose, and will be aided in doing so by a course of exercises to improve the respiratory functions of the chest, with country or seaside air, good food, and iodide of iron to relieve anæmia and congestion. The *treatment* consists in removing them, which may be done in several ways. The softer ones may be scraped away with the nail of the finger behind the palate ; those about the Eustachian tubes and side of the pharynx are best extirpated by Meyer's ring knife (Fig. 386) introduced through the nose ; and the larger ones, which are situated on the

Fig. 386.—Meyer's ring knife.

roof and back of the pharynx, by Loewenberg's forceps (Fig. 387) and Gottstein's curette passed behind the palate. The pharyngeal tonsil which is usually hypertrophied in connection with adenoid growths can be readily removed by these forceps. Nitrous oxide gas with a little ether, followed if necessary by some chloroform blown in, is the safest anæsthetic procedure. Chloroform used alone should be given in very small quantities, and never be pushed beyond the "pin-point pupil." Some surgeons recommend the hanging-head position, but this interferes with the complete removal of the growths. We always have the head on its side, so that the blood may run into the cavity of the cheek, whence it can be readily

Fig. 387.—Walsham's modification of Loewenberg's forceps for removing adenoid vegetations.

sponged away. When scraping is carried to excess, severe primary or secondary hæmorrhage may arise. No after treatment, beyond insisting that the child should be trained to breathe through the nose, is usually required ; but the mouth may usefully be kept closed at night by a four-tailed bandage. We never employ the syringe, as we believe it is one of the chief causes of the middle-ear trouble or resuscitation of ear disease which sometimes occurs after the removal of these growths. As a precaution against cold, the patient should be confined to his bed or room for a few days. Children should always be carefully prepared for the operation. Deaths occasionally occur among "out-patients" from neglect of this precaution.

Rhinoscleroma, which is unknown in this country except in immigrants, is prevalent in South-west Russia, Austria, Silesia, and

Central America. It is caused by a specific bacillus and is characterised by the formation of smooth, hard, dense, plate-like or nodular masses of tissue beneath the mucous membrane and skin of the nose. It usually begins in the interior of the nose and spreads forwards to the upper lip or backwards into the pharynx and may lead to complete stenosis of the nasal cavities and great external deformity. The stony hardness, rigidity, slow growth and absence of pain, of inflammation and of ulceration make it quite unlike any other disease. *Treatment.*—In the early stages the growth should be freely excised; later something may be done to restore nasal breathing by cutting portions away or by burning a passage with the cautery. Injections of a glycerine extract of the rhinoscleroma bacillus are said to have been attended with some success.

DISEASE OF THE ACCESSORY SINUSES OF THE NOSE.

Empyema of the maxillary antrum.—This sinus is an air space in the upper jaw lined with thin mucous membrane and communicating with the middle meatus of the nose by an opening about one inch above its floor. Into the floor project the roots of the molar teeth, which are separated by only a very thin plate of bone; but the roots of any of the teeth in the upper jaw may communicate with it (Fig. 388).

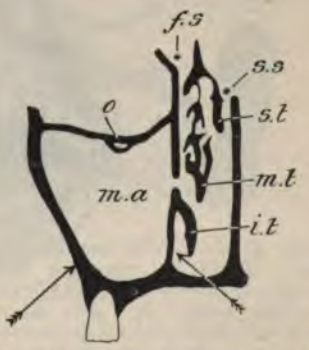

FIG. 388.—The maxillary antrum. *i.t*, *m.t*, *s.t*, Inferior, middle and superior turbinals. *m.a.* Maxillary antrum opening into middle turbinal fossa. *f.s.* Frontal sinus and infundibulum, into which open anterior ethmoidal cells. *s.s.* Orifice of sphenoidal sinus. *o.* Infra-orbital canal. Compare Fig. 390. Arrows show the points at which the antrum is punctured.

Empyema of the antrum is a collection of muco-pus prevented from escaping into the nose owing to the orifice being obstructed, or owing to the fact that it is above the level of the floor. The empyema may form in course of an acute inflammation, especially during influenza, or may occur as a subacute affection by extension from a dental alveolus, and less commonly from necrosis of bone; or it may be a mere chronic retention, owing to the orifice being blocked by nasal polypi. An empyema may rarely be the result of an acute osteomyelitis of the walls of the maxillary antrum, set up by septic inflammation in the mouth, such as cancrum oris, or it may follow gonorrhœal conjunctivitis.

The *signs* are neuralgic pain and inflammatory swelling of the cheek, with fever. Pus may escape from the nose, pale yellow, intermittent in its flow, and its odour will then be perceived,

especially by the patient; whereas in atrophic ozæna the patient may be unconscious of the foul odour, so evident to bystanders. It flows when the patient's head is bent forwards, or may be directed backwards into the pharynx and disturb the patient's appetite. The interior of the nose should be wiped free of pus, and the patient's head bent, after which the meatus will be again full. When it does not escape the signs of tension are more marked. Pus may then be found by pushing an exploring syringe through the cocainised wall of the inferior meatus into the antrum.

Transillumination of the upper jaw serves to confirm this. The patient is seated in a dark room, or is examined under a photographer's cloth, supported by an umbrella. A small electric lamp

Fig. 389.—Puncture of the maxillary antrum through the canine fossa.

is placed in the mouth and the lips closed, when a dull glare will illuminate the sound cheek and pupil, leaving the pupil on the diseased side and the infra-orbital region partly in shadow. It is this unequal illumination of the two sides which is important for diagnosis. If neglected, the empyema may burst on the cheek or lead to necrosis of the upper jaw, or there may be septic absorption resulting in pyæmia; or septic thrombosis of the orbital veins may occur, producing proptosis or acute optic neuritis; or the thrombosis may extend further back to the cavernous sinus and brain, setting up meningitis.

Treatment.—The antrum is conveniently drained through the canine fossa (Fig. 389) by turning up the lip and piercing the anterior wall with a triangular perforator, and the hole enlarged if necessary by a gouge. Through this the pus and polypoid thickened mucous

membrane may be removed by a sharp spoon and the cavity filled with gauze for twenty-four hours. The cavity is washed out frequently with Condy's fluid, or better chinosol, until the opening in the gum has healed. At times a counter-opening may be made with advantage into the inferior meatus, by which an escape for the secretion of the antrum on the level of the floor is provided. If there is a carious tooth which has to be removed, the antrum may be perforated through the socket, a short cannula fixed to a dental plate inserted, the cannula being closed by a split plug with a knob to facilitate withdrawal, which can be done at any time for washing out. When the lining of the antrum has returned to the normal the cannula can be dispensed with. In less severe cases where the mucous membrane of the antrum is not diseased, a simple puncture of the antrum either through the canine fossa, or tooth socket, or the wall of the inferior meatus, and washing out with chinosol through a cannula, which is allowed to remain *in situ* in the intervals, will suffice to cure the empyema. Walsham has employed this method many times with perfect success.

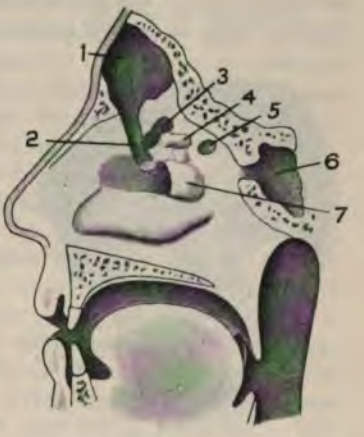

FIG. 390.—Sinuses opening into the upper part of the nose. 1. Frontal sinus. 2. Infundibulum. 3. Opening of anterior ethmoidal cells. 4. Superior turbinal. 5. Opening of posterior ethmoidal cells. 6. Sphenoidal sinus. 7. Middle turbinal partly cut away.

Mucocele and empyema of the frontal sinuses (Fig. 390).—*Mucocele.*—Retention of mucus may occur in the frontal sinus owing to swelling and hypertrophy of the nasal mucous membrane over the middle turbinal, or to the formation of polypi in that region. The anterior wall of the sinus after a time becomes thinned and a fluctuating swelling forms on the forehead to one or both sides of the middle line. An acute inflammation of the nasal mucous membrane, such as may be set up by influenza, may spread up the infundibulum to the frontal sinuses, giving rise to an *empyema* with or without an intermittent discharge of pus into the nose.

The *symptoms* are frontal headache, and when there is suppuration, severe frontal pain, and redness and œdema of the forehead and eyelids, and later fluctuation and pointing. With this is a continuous discharge of pus through the infundibulum, or the passage of a probe into the infundibulum may push aside polypoid granulations, and be followed by a flow of pus.

Treatment.—The retention of mucus, *mucocele*, in the frontal sinus may be relieved by excising the anterior end of the middle turbinal and any polypi that may be found growing from it, and by then washing out the sinus through a frontal sinus cannula. The one thing which should not be done is the puncturing or incising of the mucocele on the forehead. An *empyema* of some standing is nearly always associated with polypi in the sinus, or a polypoid condition of the mucous membrane. It should therefore be opened at once by an external incision.

The best method is a curved or angular incision about 1½ inch in length through the lower margin of the eyebrow down to the bone (Fig. 391). The periosteum and pulley of the superior oblique muscle if seen is pushed towards the orbit. Then the floor of the frontal sinus is entered through the roof of the orbit just behind the inner angle, which is the lowest part (Fig. 391). The frontal sinus has a variable extent, from a little dilatation at the head of the infundibulum to a cavity extending out to the external angle of the orbit just above the eyebrow. In a certain number of cases, some have said in nearly half, there is a free communication between the frontal sinuses of the two sides. The whole of the frontal sinus cavity is now scraped out and treated with an antiseptic including the infundibulum; a re-communication of the frontal sinus with the nose is in this way established. Then the sinus is packed with a narrow strip of iodoform gauze, the end of which is brought out through the wound. Two or three inches of the gauze is drawn out daily, and in a fortnight the sinus should be lined with healthy granulations. Then the skin wound may be allowed to heal, which it will do leaving very little of a scar. This method is more certain than that of passing a rubber tube from the sinus into the nose for drainage, and closing the external wound.

Fig. 391.—Frontal sinus operation. On the right side is shown the line of the incision; on the left side, the opening made into the sinus.

Disease of ethmoidal and sphenoidal sinuses (Fig. 390).—The ethmoidal sinuses lie along the inner wall of the orbit, the sphenoidal cells behind them in the base of the skull. Ethmoid mucocele produces a swelling on the inner side of the orbit, pushing the eye out and causing squint. Ethmoid and sphenoid empyema give rise to deep-seated pain in the orbit and back of the nose. Exophthalmos, ptosis, strabismus, retro-bulbar neuritis, and blindness

may occur by involvement of the nerves of the eyeball at the back of the orbit.

Treatment.—The anterior ethmoidal cells may be reached from the inner angle of the orbit by a similar incision as for the frontal sinus, but extending it down the inner border of the orbit. More generally they are carefully curetted from the nose, regard being had to the nearness of the cavernous sinus and the meninges. The sphenoidal sinuses can only be reached through the nose.

DISEASES OF THE PHARYNX.

Pharyngitis, or inflammation of the pharynx, is commonly of the catarrhal variety (*acute and chronic pharyngitis*) but it may fall chiefly on the glands of the pharynx (*follicular or granular pharyngitis*), or more rarely, may spread deeply and end in suppuration (*phlegmonous pharyngitis*). At times it is attended with deficient secretion and atrophy of the mucous membrane (*pharyngitis sicca*), and occasionally assumes an *erysipelatous* character, and is then generally associated with erysipelas of the face. Here a few words only can be said on the *phlegmonous* form, which, perhaps, more commonly comes under the care of the general surgeon. It is usually the result of a streptococcal or mixed infection, and sometimes follows an injury. The pharynx is intensely red and swollen, the neck often brawny and œdematous (*Ludwig's angina*), swallowing is difficult or impossible, respiration is laboured, and death may occur in a few days from sudden spasm of the glottis, or from exhaustion and blood poisoning. The *treatment* consists in inhalations of steam impregnated with carbolic acid; free incisions if pus forms in accessible situations; the administration of fluid nourishment and stimulants, in the form of enemata if the patient is unable to swallow; and the performance of instant tracheotomy if œdematous laryngitis supervenes. If streptococci are found in bacterial examination, the injection of the anti-streptococcus serum may be expected to do good.

Ulceration generally occurs in connection with like ulceration of the palate, fauces, and tonsils. (See *Tonsils.*) Here it need only be said that the healing of the ulcers, especially those of the tertiary syphilitic variety, is sometimes productive of great deformity. Thus, 1, the soft palate may become glued to the back of the pharynx; or 2, to the base of the tongue; and 3, the lower part of the pharynx may be narrowed just above the entrance to the larynx, rendering deglutition difficult, and subjecting the patient to the risk of suffocation from the lodgment of food at the constricted part. *Treatment.* — Adhesions between the palate and pharynx should be carefully divided and re-adhesion prevented by the use of plugs. When contraction or *stenosis* of the lower pharynx has occurred, the cicatricial bands should be divided in a backward

direction with a guarded knife and recontraction prevented by the daily passage of a bougie. Walsham has found a Ricord's urethrotome answer admirably for making the division. If the introduction of instruments causes much spasm, tracheotomy should be previously performed.

Postpharyngeal abscess (Fig. 392) is a collection of pus in the loose cellular tissue behind the pharynx. It is generally chronic, and due to disease of the cervical vertebræ in children, or more

Fig. 392.—Postpharyngeal abscess. A. Abscess cavity. B. Œsophagus. C. Entrance to larynx. (St. Bartholomew's Hospital Museum.)

rarely of the mastoid or base of the skull; but it may be acute, and is then usually the result of an injury, as swallowing acids or the impaction of a foreign body, or of the exanthemata, phlegmonous pharyngitis, etc. It sometimes occurs without apparent cause; there is then often a history of syphilis or of tubercle. In the latter instance it is probably due to the breaking down of the prevertebral lymphatic glands. It may break into the pharynx, or at the side of the neck; or even make its way into the mediastinum.

Symptoms.—Pain, difficulty in opening the mouth, obstructed deglutition and respiration, the presence of a fluctuating swelling at

the back of the throat, and more or less swelling about the angle of the jaw. When the abscess is acute, there is commonly some febrile disturbance. *Treatment.*—When it depends upon disease of the spine the abscess should be opened through the side of the neck behind the sterno-mastoid and treated like other tuberculous collections. In other cases a vertical incision should be made in the middle line through the posterior pharyngeal wall with a properly guarded knife, the swelling having been previously punctured with a long exploring trocar and cannula, so as to relieve tension by letting some of the pus escape. The pharyngeal wall should be painted with cocain and the patient seated in a chair. Walsham has opened many postpharyngeal abscesses in this way, and much prefers it to the more elaborate method of an incision through the neck. There is no danger of suffocation as the patient, not being under an anæsthetic, can cough up and spit out any pus that may tend to enter the larynx. The wound heals rapidly, and the patient is practically well in a few days. If opened under an anæsthetic, the head should be in the hanging position or should be turned to the side to allow the pus to escape through the mouth, as suffocation has occurred through a sudden gush into the air passages.

Tumours of the pharynx are rare, though all varieties may occur. When arising in the loose cellular tissue behind the pharynx, the more common situation, they are spoken of as *postpharyngeal* tumours. The softer varieties of sarcoma closely simulate abscess, but the absence of fluctuation, and of pus on puncture will settle the diagnosis. Epitheliomata in the pharynx whilst still quite small often give rise to great enlargement of the glands in the neck. Innocent growths, when small and unattached to the vertebræ, may be enucleated through a vertical incision over them. The malignant, as a rule, should be left alone.

DISEASES OF THE LARYNX.

Physical examination of the larynx.—For the diagnosis and efficient treatment of the diseases of the larynx the laryngoscope is required. Throw the light reflected from the head mirror into the back of the patient's mouth; draw the tongue, held by a towel or square of Japanese paper with the left hand, gently forward, and press the throat mirror, held in the right hand, firmly but gently against the uvula and soft palate. The back of the mirror must be warmed to blood-heat or the mirror smeared with soap and gently polished. With a little practice an image of the larynx is obtained. Ask the patient to pronounce the sounds *ah*, *ee*, and the vocal cords will come into view. The image of the larynx is of course reversed, the front appearing in the throat mirror as the back. If any difficulty is experienced in obtaining

a good view the soft palate and back of the mouth should be sprayed or painted with a solution of cocain 20 per cent., or eucain 10 per cent. If any operation or manipulation is required in the larynx itself, it also should be swabbed with cocain or eucain by the laryngeal brush.

Laryngitis, or inflammation of the larynx, may be conveniently divided into—1, acute catarrhal; 2, chronic catarrhal; 3, œdematous; and 4, membranous laryngitis.

Acute catarrhal laryngitis may be due to sudden exposure to cold or damp, violent exertion of the voice, or inhalation of noxious vapours or impure air; or the inflammation may spread to the larynx from the pharynx; or occur in the course of other diseases, as the eruptive fevers. *Symptoms.*—Soreness of the throat, hoarseness or even aphonia, laryngeal cough, and tenderness on pressure over the thyroid cartilage, accompanied by febrile symptoms. On laryngoscopic examination the parts are seen red and swollen, and the cords do not come together properly. The *treatment* consists in rendering the atmosphere moist by the steam kettle, in inhaling soothing vapours, and abstaining from using the voice; whilst if the attack is very acute, leeches or cold in the earlier stages may be applied over the thyroid cartilage. Should the inflammation assume the œdematous form, scarification, intubation, or tracheotomy may become necessary (see *Œdematous Laryngitis*).

Chronic laryngitis may be due to exposure to wet and cold, overexertion of the voice, excessive smoking, inhalations of dust or noxious vapours, syphilis, tubercle, and malignant disease. The mucous membrane appears thickened and indurated and covered with a muco-purulent discharge, whilst the glottis is narrowed in consequence of the thickening of the mucous membrane. The *symptoms* are cough, hoarseness, loss of voice, dryness and irritation of the throat, and dyspnœa, varying with the amount of narrowing of the glottis. A variety of chronic laryngitis, in which the mucous follicles are chiefly affected, is known as follicular or granular laryngitis, or clergyman's sore throat, and is frequently associated with a similar condition of the pharynx. *Treatment.*—The application with the brush of a strong solution of nitrate of silver (half a drachm to the ounce, or even stronger), absolute rest of the voice, residence at a suitable spa, avoidance of all sources of irritation, and appropriate remedies if there is any specific disease.

Œdematous laryngitis or œdema of the glottis.—In this form there is an effusion of serous fluid into the submucous tissue of the larynx, especially that about the aryteno-epiglottidean folds (Fig. 393). But the œdema does not extend below the vocal cords, as the mucous membrane is tightly attached to them without the intervention of any submucous tissue. *Cause.*—It generally comes on suddenly, and often supervenes upon some previous inflammatory

condition of the larynx or neighbouring parts. It is of common occurrence after scalds or burns of the throat, stings of insects, or the impaction in the larynx of a foreign body; or it may occur in the course of such diseases as erysipelas, fevers, and smallpox; or be engrafted on tuberculous or syphilitic ulceration of the larynx, perichondritis, or necrosis of the cartilage. Œdema of the larynx of a passive character is also a frequent termination of Bright's disease. The *symptoms* in the acuter forms are most urgent, the dyspnœa is extreme, and if not relieved rapidly ends in spasm and death. When less acute the voice is affected, inspiration is often stridulous and laboured, and swallowing may be painful and difficult

FIG. 393.—Œdematous laryngitis. (St. Bartholomew's Hospital Museum.)

FIG. 394.—Membranous laryngitis or croup. (St. Bartholomew's Hospital Museum.)

—symptoms which may be followed by cyanosis, coma, and death. The *treatment* must be energetic; an emetic should be given at the onset, and leeches, ice, or, if preferred, hot sponges, applied over the thyroid cartilage. These means failing, the œdematous part must be scarified by the laryngeal lancet, or an O'Dwyer's tube, if at hand, passed through the glottis, and retained there until the œdema subsides; otherwise laryngotomy or tracheotomy must be performed.

Diphtheria of the larynx, membranous laryngitis, or laryngeal croup, is an infectious disease especially of childhood, and may either begin in the larynx, or spread to it from the fauces and pharynx. It is characterised by the formation of a false membrane, which may extend into the trachea and bronchi (Fig. 394). The membrane, which may be hard and tough, or soft and crumbling, and of a yellowish or greyish-white colour, is produced by the

coagulation of fibrinous material exuded on the surface of the mucous membrane. It consists of a delicate network of fibres enclosing leucocytes, cast-off epithelium, and granular débris in its meshes. The Klebs-Loeffler bacillus is found in the membrane. On its separation the mucous membrane beneath is generally, though not invariably, found to be denuded of epithelium, congested and inflamed; but the mucosa is not usually involved as is the case in diphtheritic inflammation of the fauces and pharynx. This difference would appear to depend on the site of the inflammation and intensity of the process. The *symptoms*, when the disease begins in the larynx, generally come on very gradually; and at first cannot be distinguished from an ordinary catarrh. Soon, however, and often first during the night, the cough acquires a ringing or brassy character, and soon afterwards, if not simultaneously, the inspiration becomes stridulous, and later the voice "hoarse, cracked, and whispering, or in young children, totally suppressed." Dyspnœa is now marked; the soft parts of the chest-walls recede during inspiration; the inspiration is heaving; expiration as well as inspiration may also become impeded, and the child, if not relieved, rapidly becomes cyanosed and dies. When the disease spreads from the pharynx, the laryngeal signs may at first be masked; but later, they are similar to those given above. Great care must be taken against infection both by the practitioner and nurse. Material may be coughed into the face or eyes, or be carried to the mouth with the hands. In examining the child a glass or talc shield may be fixed on the tongue depressor or a mask of lint put over the face. A bowl of antiseptic lotion is required in which to dip the hands. *Treatment.*—Internally quinine and perchloride of iron may be given, whilst locally when any membrane is visible on the fauces and pharynx it should be removed, and prevented, if possible, from re-forming by swabbing out the throat at frequent intervals with boro-glyceride, perchloride of iron, lactic acid, carbolic acid, or other disinfectant. The child may be placed under chloroform, if necessary, to ensure the thorough removal of the membrane. The subcutaneous injection of diphtheria antitoxin is of undoubted efficacy, since a marked decrease in the percentage of mortality from diphtheria has resulted in the hospitals where it has been used. It would appear that the earlier the injections are made in the disease the more prospect there is of success since the antitoxin can only neutralise the toxin present in the system, not undo the damage to the muscles and nerves already done, nor control the secondary septic processes which may have been set up. The dose must be sufficiently large and should be regulated more by the severity of the symptoms than by the age of the patient. It must be calculated by immunising units and not by volume. Never less than a thousand such units should be administered in a single dose, and this should be repeated every two, three, or four hours till all danger is over.

Should the larynx become obstructed, *tracheotomy* must be performed. The chief indications for this operation are—1, retrocession of the soft parts of the chest walls; 2, suppression of the voice; and especially 3, impeded expiration. Before introducing the tracheotomy-tube the membrane should be thoroughly removed both from the trachea and larynx by a feather or by the suction-tube apparatus, and its re-formation if possible prevented by constant spraying of the part through the tube with an alkaline lotion or lactic acid. The atmosphere should be kept moist by steam to which an antiseptic is added. The patient should be fed with soft solid nourishment, and if necessary by a flexible silk tube passed through the nose. Stimulants are generally required. The recumbent posture should be insisted on for some weeks, as there is grave danger, if the patient attempts to sit up, of sudden and fatal cardiac syncope.

Tubercle of the larynx, also called laryngeal phthisis, may sometimes occur as a primary affection, though it is generally secondary to tubercle of the lung. It is characterised by the formation of miliary tubercles under the mucous membrane, which subsequently break down, leading to ulceration. The *symptoms* are those of ordinary chronic laryngitis, but in addition to these, the patient often presents signs of pulmonary phthisis. On examination the mucous membrane looks pale, and the aryteno-epiglottidean folds swollen and often of a pyriform shape; later, ulceration will be discovered, and may be followed by caries and necrosis of the laryngeal cartilages, dysphagia, and œdema of the glottis. *Treatment.*—The usual constitutional treatment for tuberculous diseases must be employed, combined with guaiacol (℥j. in capsules three times a day). Lactic acid (10 per cent. to 70 per cent.) should be applied to the ulcerated surface, or after first curetting if ulceration has not as yet occurred. The insufflation of morphia or orthoform and painting the part with cocain before taking food may be tried to relieve the cough and the difficulty and pain in swallowing. Should swallowing become impossible, the patient should be fed with the œsophageal tube or suck through a tube whilst lying face downwards. Tracheotomy must be performed if suffocation threatens.

Syphilis of the larynx.—In the secondary stages of syphilis, catarrhal inflammation, superficial ulceration, and mucous patches may occur; whilst in the tertiary stages characteristic ulcers due to breaking down of gummata are not very uncommon. Tertiary ulceration may extend to the perichondrium, or a gumma may begin beneath that membrane, and in either case lead to necrosis or caries of the cartilages. On the healing of the ulcers contractions and adhesions producing stenosis of the larynx may ensue. General syphilitic *treatment*, appropriate to the stage, should be employed. Scarification or tracheotomy is called for in tertiary affections should œdema of the glottis supervene. In *stenosis* an attempt may be

made to dilate the contracted glottis by means of O'Dwyer's tubes, or the stricture may be divided with a guarded knife or with the galvano-cautery. But usually the patient is reduced to wearing permanently a tracheotomy tube.

Tumours both innocent and malignant occur in the larynx. Of the former the papillomata and fibromata are the most common, of the latter the epitheliomata. The *papillomata* occur as warty or pedunculated excrescences, or as soft, flocculent, villous-like bodies, and generally grow from the vocal cords and front of the larynx (Fig. 395). They may be single or multiple. The *fibromata* are less common, and occur as small, smooth, solitary, spherical, pedunculated, or sessile growths, springing from the vocal cords. The

Fig. 395.—Papilloma of larynx. (St. Bartholomew's Hospital Museum, No. 1648.)

Fig. 396.—Sarcoma of larynx. (St. Bartholomew's Hospital Museum, No. 1653.)

epitheliomata usually grow from the mucous membrane covering the arytenoid cartilages, or from the ventricular bands or cords. A *sarcomatous* tumour growing from the right aryepiglottic fold is shown in the accompanying illustration (Fig. 396).

The chief *symptoms* of a growth in the larynx are hoarseness or aphonia, and dyspnœa. When the growth is pedunculated the symptoms are often paroxysmal and intermittent in character, in consequence of the growth being moved by the current of air in respiration. The laryngoscope is essential for the diagnosis. In the early stages it may be difficult to distinguish an innocent from a malignant tumour, but if a small piece can be removed, a microscopical examination will usually clear up the point. Later, the rapid growth of the tumour, its tendency to ulcerate, its induration, its involvement of surrounding parts, as indicated by the immobility of the affected cord, the enlargement of lymphatic glands, and the

accompanying pain and cachexia will indicate malignancy. Frequently, however, the lymphatic glands are not involved till late in the disease, and there may be no cachexia.

Treatment.—Innocent growths should be removed if possible by the intra-laryngeal method. This may be done by evulsion with the laryngeal forceps, or by excision with the cutting forceps, or with the cold wire or galvano-cautery snare, local anæsthesia being induced by cocain or eucain. The multiple papillomata which sometimes occur in children as the result of laryngeal irritation may be removed by combining the administration of a little chloroform with the application of cocain, the child being held in the position seen in Fig. 403. If they recur tracheotomy should be done, and after six months the growths will be found to have disappeared. When the growth is of very large size, or broad-based, or situated below the cords, or in other parts where it cannot be removed by this method, laryngo-tracheotomy or thyrotomy may have to be performed. A small epithelioma of one of the vocal cords unattended by glandular enlargement can most successfully be removed by thyrotomy and the complete cutting away of the growth with the affected cord. For a large malignant growth, if confined entirely to the larynx, and the glands of the neck are not involved, thyrotomy may still be performed, and the growth completely cut and scraped away from the cartilages, or if the cartilages are found invaded, part, or even the whole of the larynx may be extirpated. Otherwise palliative treatment only can be employed, or tracheotomy performed if suffocation threatens.

OPERATIONS ON THE AIR PASSAGES.

Under this head are included *tracheotomy*, *laryngotomy*, *laryngo-tracheotomy*, *thyrotomy*, *subhyoid pharyngotomy*, and *intubation* and *extirpation of the larynx*. A. Tracheotomy, laryngotomy, and laryngo-tracheotomy may be required, 1, for establishing a permanent opening below an obstruction of the larynx; 2, as a temporary expedient until such an obstruction can be removed; 3, for the extraction of a foreign body or growth; and 4, to prevent blood entering the trachea during operations about the mouth, jaws, tongue, and pharynx. B. Thyrotomy and subhyoid pharyngotomy may be necessary for the removal of a growth or foreign body when such cannot be extracted by the intra-laryngeal method or by one of the former operations. C. Complete or partial extirpation of the larynx may have to be undertaken for a malignant growth confined to the larynx. Before performing any of these operations the surgeon should consider well the anatomy of the middle line of the neck. Beginning at the chin is the raphé between the mylohyoid muscles, next the hyoid bone, and then the thyro-hyoid membrane through which an incision is made in the operation of *subhyoid pharyngotomy* (Figs. 397, a, and 400, a). Below this is the pomum Adami, with

the notch in the thyroid cartilage which, though prominent in adults, especially in males, can hardly be felt in the fat neck of a child. An incision exactly in the middle line through the thyroid cartilage is known as *thyrotomy* (Figs. 397, b, and 400, b). A little below the thyroid cartilage the cricoid can be felt. It is situated opposite the fifth or sixth cervical vertebra and is an excellent landmark, and it can always be distinguished, however fat the neck. Between it and the thyroid cartilage is the crico-thyroid membrane, which is quite superficial, being covered only by the skin, superficial and deep fascia, and the overlapping sterno-hyoid muscles. This is the spot where *laryngotomy* is performed (Figs. 397, c, and 400, c). Below the cricoid cartilage are two

Fig. 397.—Situation of incisions for operations in middle line of neck. a. Subhyoid pharyngotomy. b. Thyrotomy. c. Laryngotomy. d. Tracheotomy above isthmus. e. Tracheotomy below isthmus. The lines only show the relative situation of the incisions, not their correct length.

or three rings of the trachea, and then the thyroid isthmus. There is usually a space between the cricoid cartilage and the isthmus of a quarter to half an inch. Here the trachea is merely covered by the skin, superficial and deep fascia, and the overlapping sterno-hyoid muscles on either side, and it is in this situation that *tracheotomy* is best performed (Figs. 397, d, and 400, d). When the incision is extended upwards through the cricoid as well as through the upper rings of the trachea, it is called *laryngo-tracheotomy*. After the isthmus of the thyroid gland, which, in adults, is usually about half an inch wide, follow four or five rings of the trachea, and then the upper border of the sternum. Below the isthmus the trachea recedes from the surface, and in addition to the skin and superficial and deep fascia, is covered by the sterno-thyroids as well as the sterno-hyoids, and by

two layers of deep fascia between which is the large inferior thyroid plexus of veins. Superficial to the muscles, the anastomotic branch between the anterior jugular veins also crosses the trachea. On the trachea itself are several small branches from the inferior thyroid arteries, and sometimes the thyroidea ima, an abnormal branch coming off from the aorta; whilst, rarely, the innominate vein may be higher than usual, and cross the trachea above the level of the sternum. On either side of the trachea, low in the neck, are the carotid arteries. Some surgeons perform tracheotomy below the isthmus (Fig. 397, e, and 400, e); but a review of these anatomical relations makes it evident how much greater is the risk and difficulty then attending it.

Fig. 398.—Parker's tracheotomy tube.

Tracheotomy may be performed either above or below the thyroid isthmus. The former situation should, as a rule, be chosen, as here the operation can be performed with greater ease and less risk. Moreover, there is less danger of suppuration extending between the layers of the cervical fascia which are necessarily opened if the low operation is done. In favour of the low operation, on the other hand, is the fact that the opening is further from the disease when the larynx is affected, and nearer to the bronchi when a foreign body has to be extracted; moreover, there is sometimes more room below the isthmus, as the latter may touch the cricoid cartilage. The isthmus, however, can be drawn downwards quite

Fig. 399.—Tracheotomy dilators.

easily with blunt hooks, or, if necessary, may be divided in the middle line with perfect safety and practically no hæmorrhage. The low operation may be required for malignant disease of the larynx, thyroid or cervical lymphatic glands, in order to open the trachea well below the disease. The safest plan is then to take the larynx as the guide and follow the trachea downwards.

Tracheotomy may be done either with or without an anæsthetic. Chloroform should, as a rule, be given to children, as otherwise their struggles are apt to embarrass the operator. In adults, however, it is not necessary, as after the skin incision has been made

no pain is felt, and chloroform is liable to increase the dyspnœa, if present, to a dangerous extent and necessitate the operation being rapidly performed, whereas the more deliberately it can be done, the less is the risk attending it. If preferred, a little nitrous oxide gas may be given, or cocain or eucain may be injected. A small pillow having been placed beneath the neck so as to render it prominent, make an incision from the cricoid cartilage, exactly in the middle line, for an inch and a half to two inches downwards according to the age of the patient, fatness of the neck, etc. (Figs. 397, d, and 400, d). Divide the skin and superficial fascia, and having found the interval between the sterno-hyoid muscles continue your incision between them, carefully avoiding any large veins. The isthmus of the thyroid will now be seen in the lower part of the wound as a bluish-red body; and if sufficient room does not exist between it and the cricoid cartilage, draw it down gently with a blunt hook; or if this cannot be readily done, notch it in the middle line or divide it. The drawing downwards of the isthmus is greatly facilitated by dividing transversely on the cricoid the layer of fascia which extends from the cricoid cartilage to the isthmus. By doing this, moreover, the wounding of the veins between the layers of fascia will be avoided. The first two or three rings of the trachea having now been fully exposed, and all arterial hæmorrhage arrested by ligature or pressure-forceps, thrust the sharp hook into the trachea immediately below the cricoid cartilage, and, steadying it in this way, divide the first two or three rings by thrusting in the knife with the back of the blade directed downwards and by cutting towards the cricoid. Venous hæmorrhage, except from a large vein, which of course should be tied or clamped, need not delay the opening of the trachea, as it depends on engorgement of the right side of the heart, and will disappear after two or three inspirations through the tracheal wound. The wound in the trachea being held open by the tracheal dilator, pass the outer tube, made wedge-shaped, by pressing it between the finger and thumb, into the trachea, and then immediately insert the inner cannula, as until this is done, air cannot freely pass through the tube. Secure the tube *in situ* by tracheotomy tapes tied behind the neck. Where the operation is performed for croup or diphtheria, the tube should not, as a rule, be inserted at once, but the wound held open by the dilator, and any false membrane removed by a feather passed both down into the trachea and up into the larynx, or if this does not succeed, by a Parker's suction-tube apparatus. The bivalve cannula in general use is apt, on account of its shape, to produce ulceration of the anterior wall of the trachea, on which from its curve it must necessarily impinge; it has even been known to perforate the wall and to enter the innominate artery. This can be prevented by the improved shape of the cannula invented by Mr. R. W. Parker (Fig. 398). Should the breathing

cease during the operation the trachea should still be opened, the obstructing membranes removed, and artificial respiration persevered in for some time.

Dangers and difficulties of the operation.—Where the operation can be done deliberately, and on a patient with a thin neck, it is attended with no great difficulty; but where, as is frequently the case, it has to be undertaken on an emergency, possibly with insufficient light and with no skilled assistant at hand, or on a young child or infant with a fat neck, and has to be completed rapidly to prevent death from suffocation, it is perhaps one of the most trying that the surgeon is called upon to perform. The

FIG. 400.—Incisions in certain operations on the neck. a. Subhyoid pharyngotomy. b. Thyrotomy. c. Laryngotomy. d. Tracheotomy above, and e below, the isthmus of thyroid. f. Ligature of subclavian (3rd part). g. Ligature of lingual. h. Ligature of temporal; exposure of auriculo-temporal nerve. i. Ligature of common carotid.

dangers into which the inexperienced and unwary may then fall are the following:—

1. *The hyoid bone or the thyroid cartilage* may be mistaken for the cricoid cartilage, and the incision made through the thyro-hyoid membrane or into the thyroid cartilage. This mistake could hardly occur except in a fat-necked child, and then only through carelessness in not determining the position of the cricoid cartilage before beginning the operation.

2. *The interval between the sterno-hyoid muscle may be missed*, and the dissection carried to one or other side of the trachea. The thyroid body and even the carotid artery has in this way been wounded. To avoid such a disaster the head should be held perfectly straight and the incision made accurately in the middle

line; one side of the wound should not be retracted more than the other; and the index finger should be used from time to time to make sure that the dissection is being made over the trachea.

3. *Too short an incision may be made*, and consequently be a source of embarrassment in drawing down the thyroid isthmus, and in defining the trachea before it is opened. The incision should never be less than an inch and a half long even in a child.

4. *One or more large veins may be wounded*, and the steps of the operation be considerably impeded by hæmorrhage. Their walls are very thin: great care therefore is necessary to avoid injuring them.

5. *The knife may perforate the posterior wall of the trachea* and enter the œsophagus. Caution, therefore, is necessary, and some advise that the knife should be held, whilst incising the trachea, with the forefinger placed on one side half an inch from its point, so that it cannot penetrate too deeply.

6. *The knife may slip to one side*, instead of entering the trachea. This can hardly happen if the trachea is fixed by the sharp hook and drawn well forward into the wound whilst being perforated.

7. *The innominate vein and even the innominate artery have been wounded* in incising the trachea during the performance of the low operation. The knife, therefore, should be introduced with the back of the blade towards the sternum, and the incision made from below upwards.

8. *Blood may enter the trachea*, and if allowed to remain there will coagulate, and the clots, being drawn into the bronchi and acting as plugs, may cause suffocation. This danger should be guarded against by clamping all bleeding vessels, and thoroughly exposing the trachea before incising it, lest there should be a vessel in front of it. Should only a little blood enter the trachea, it can be coughed up; but if the amount is large, the patient's head should be depressed, the wound of course being held open by retractors, to allow the blood to run towards the mouth instead of downwards into the bronchi. Where there is a general oozing of blood from the wound, the introduction of the tube will arrest it by relieving the cyanosis.

9. *The tracheotomy tube may be forced between the fascia and the front wall of the trachea; or one valve of the tube may be passed inside the trachea and the other outside.*—To escape these accidents the incision in the trachea should be free, and its edges well retracted, or one edge may be held by a sharp hook.

10. *The tube, where membrane is present, may be passed between the tracheal wall and the false membrane*, a danger that may be guarded against by removing the membrane before introducing the tube.

11. *The tube has been passed upwards into the larynx instead of*

downwards into the trachea.—No excuse, and it is to be feared no remedy, could be found for such gross ignorance.

After-treatment.—The room should be kept at a uniform temperature, the air rendered moist by means of a steam-spray apparatus, but the bed should not be surrounded with curtains as was formerly advised. The inner tube, especially if the operation is performed for diphtheria or croup, should be freed at frequent intervals with a feather, or with a small sponge fixed on a wire, and well cleansed by the nurse at least two or three times a day. The outer tube, which also requires cleansing once a day, should only be removed by the surgeon himself. Where it is necessary that a tube should be worn for any length of time, Mr. Morrant Baker's india-rubber cannula should be substituted for a silver tube. Walsham has employed this immediately after the operation, but it is perhaps safer not to do so until the wound has been dilated for a few days by the silver cannula, as, at first, the resiliency of the tracheal rings tends to close the wound, and the india-rubber has been found in some instances not sufficiently stiff to resist their pressure. The pilot shown in Fig. 401, inasmuch as it renders the end of the tube stiff and wedge-shaped, facilitates its introduction. The india-rubber tubes may be worn with the greatest comfort, and for prolonged periods. Walsham has now a patient who has worn them for upwards of eight years. When lined with canvas, as suggested by Mr. Baker, the tube will last in very good condition for nearly twelve months. If a silver tube be worn it should be examined on each removal, any blackening of the end, and, of course, the presence of blood, being an indication that ulceration is in progress. The tube should only be worn as long as respiration through the glottis is impeded. To determine when it may be dispensed with it is merely necessary to close the wound with the finger and thus test the breathing. As a rule, it is better to remove it at first only during the day, or for a few hours at a time, or where a fenestrated cannula is used the external opening may be stopped, for certain periods, with a plug to gradually accustom the patient to breathe through the glottis. When the tube has been worn for any length of time some difficulty is often experienced in leaving it off. This may depend chiefly on: 1, the formation of granulations in the trachea above the opening for the tube; 2, adhesions of the vocal cords to one another; and 3, paralysis complete or partial of the intrinsic muscles of the larynx. Where granulations are the cause of the obstruction, they should be touched at intervals with nitrate of silver. Where there is adhesion of the vocal cords the glottis may either be dilated by O'Dwyer's tubes, or the adhesions broken down

Fig. 401.—Walsham's pilot for Mr. Morrant Baker's soft tube.

by probes passed up through the wound or down through the mouth. The power of the muscles may be restored by galvanism, one pole being placed in the larynx, and the other over the situation of the recurrent laryngeal nerve. In children the condition improves as they grow older and as the larynx becomes more developed.

Laryngotomy.—Feel for the cricoid cartilage, and if the case is urgent, and the patient evidently *in extremis*, plunge a penknife through the skin and subjacent crico-thyroid membrane transversely, immediately above the cricoid cartilage, and hold the wound open by a hair-pin, piece of wire, toothpick, drainage tube, etc. When the operation can be done deliberately, make an incision exactly in the middle line of the neck from a little above the lower border of the thyroid cartilage to a little below the upper border of the cricoid cartilage (Figs. 397, c, and 400, c), and the crico-thyroid membrane having been thus exposed, incise it transversely, introducing the knife immediately above the cricoid cartilage, so as to be as far as possible from the vocal cords, and in order to avoid wounding the little crico-thyroid artery which anastomoses with its fellow usually across the upper part of the space. This artery, though commonly so insignificant that any hæmorrhage from it could be readily controlled by the tube, is sometimes of considerable size, and, if then wounded, would require tying. The laryngotomy tube should be somewhat compressed from above downwards, so as better to correspond with the shape of the crico-thyroid space. Some surgeons recommend that the incision through the crico-thyroid membrane should be vertical as the anterior jugular veins and the crico-thyroid muscles have been injured in making the transverse incision, and an aërial fistula has at times remained after the latter has been employed. Further, the vertical incision has this advantage, that it can be prolonged downwards through the cricoid cartilage if more room is required.

Laryngo-tracheotomy consists in prolonging the incision in the trachea through the cricoid cartilage. It is sometimes done when there is not room between the cricoid cartilage and the isthmus for the performance of tracheotomy; also for the purpose of removing a growth from the larynx. Although no harm may follow the division of the cricoid, it should be avoided, if possible, as the integrity of the larynx is thereby interfered with, and serious impairment of the vocal apparatus has occasionally been the result.

Comparison of the operations of tracheotomy and laryngotomy.—Laryngotomy is a much easier operation and can be done with greater rapidity than tracheotomy. For this reason it is *par excellence* the one to be undertaken on an emergency, as, for instance, threatened suffocation from the impaction of a portion of food at the entrance of the larynx. In children tracheotomy, or, in

the case of an emergency, laryngo-tracheotomy, should always be undertaken, as the crico-thyroid space in them is too small to admit a tube. In adults, when either laryngotomy or tracheotomy can be performed deliberately, the opinions of surgeons are somewhat at variance as to which operation ought to be undertaken for the varying conditions calling for an opening into the air passages below the glottis. We nearly always do tracheotomy (except in cases of emergency), as this operation does not interfere with the integrity of the larynx ; whereas after laryngotomy the voice has at times been lost or impaired owing to contraction of the crico-thyroid membrane, or to inflammation of the crico-thyroid joint or crico-arytenoid joint. Further, there is often difficulty with the tube.

Thyrotomy, or laying open the larynx from the front by dividing the thyroid cartilage in the middle line, may be required for the removal of a tumour or a foreign body impacted in the larynx after a thorough and careful attempt has been made to extract it by the natural passages (*intra-laryngeal method*). Make an incision accurately in the middle line of the neck from the hyoid bone to the cricoid cartilage (Figs. 397, b, and 400, b), and having exposed the thyroid cartilage, and stopped all bleeding, divide it along the angle formed by the junction of the alæ, taking care to do so in the middle line so as not to injure the vocal cords. Separate the alæ, paint the parts with cocain (10 per cent. to 20 per cent.) to allay cough and reflex vomiting, and remove the growth, etc., and bring the alæ accurately together again, and unite them by silver wire or kangaroo-tail-tendon sutures, which should not, however, be passed through the whole thickness of the cartilage. When the removal of the growth is likely to be attended with hæmorrhage, tracheotomy should first be performed and the trachea plugged by Hahn's cannula. The head should be kept low and on one side after the operation, and the tube removed, if possible, at once, or within twenty-four hours.

Subhyoid pharyngotomy consists in opening the pharynx through the thyro-hyoid membrane (Figs. 397, a, and 400, a), for the purpose of removing a tumour or impacted foreign body at the entrance or in the upper part of the larynx. It is best done by a vertical incision, extended, if need be, through the hyoid bone into the tongue, keeping strictly to the middle line. This is better than a transverse incision, as the latter is apt to give way when food is forced against it in swallowing.

Intubation of the larynx is employed as a substitute for laryngotomy or tracheotomy, in certain cases, such as œdematous laryngitis, diphtheritic laryngitis of moderate severity, and in the treatment of laryngeal stenosis. It owes its success to the apparatus (Fig. 402), invented by O'Dwyer, which must be strictly adhered to. The position in which a child is held is shown in Fig. 403 ; the tube is guided into position by the left forefinger,

which hooks forwards the epiglottis whilst depressing the tongue. In older patients the laryngeal mirror is the guide.

One hindrance to the wide use of intubation is the difficulty in introducing the tube. This, however, may be got over by practice. But a much greater difficulty is the want of trained assistance in holding the patient; moreover, the tube may be coughed up at

FIG. 402.—O'Dwyer's intubation apparatus. The gag is on the left; below it is the scale by which the proper sized tube is selected, next is the holder for introducing the tube, and next to this is the extractor. An obturator or plug, seen between the series of tubes on the right, is screwed into the holder and fits the tube. When the tube is inserted a pull on the trigger of the holder causes the teeth at the front end to push off the tube, when the obturator can be withdrawn, which is the more easy as the obturator has a hinge in the middle. The tubes are of heavy brass with expanded heads to rest on the ventricular bands, and a prominence posteriorly which rests between the arytenoid cartilages. In the centre of the tube is a fusiform enlargement which when in position is just below the vocal cords, so that the tube is thus kept in place and does not ride up. Through the head of the tube is a hole for a double ligature, by which the tube can be withdrawn out of the mouth. But when the tube is left free it is removed by the extractor, which is practically a pair of crocodile forceps with the jaws reversed. The end of the extractor is inserted into the tube and its jaws caused to separate, when the serrations on the outer aspect engage in the lumen of the tube, which can now be withdrawn.

any time, and the nurse has no means of relieving the dyspnœa as she has after tracheotomy; hence its use has mainly to be confined to hospitals, where the tube can be quickly replaced by a resident surgeon. It is also unsuitable in marked diphtheric laryngitis, for the introduction of the tube may push membrane down into the trachea which cannot be coughed up; but, on the other hand, in

cases of only temporary dyspnœa, an external wound is avoided. If an intubation tube be kept in beyond a few days, the gain over tracheotomy is lost, for a troublesome stenosis follows as a result.

Laryngectomy or extirpation of the larynx.—Partial or complete removal of the cartilages of the larynx may be required for malignant disease when the growth is confined to that organ

Fig. 403.—Intubation of the larynx (after Northrup). A child held in position whilst the surgeon is about to introduce the tube.

and the glands in the neck are not involved. First perform tracheotomy, and plug the trachea with Hahn's tampon cannula, and continue the administration of the anæsthetic through it. Next make an incision in the middle line of the neck from the hyoid bone to the tracheotomy wound, with a transverse cut at each end if more room is required; free the upper part of the trachea and the larynx from their attachments by dissecting close to these structures, securing all bleeding vessels as they are divided. Divide the trachea above the cannula and detach the larynx from the

remaining connections, working from below upwards. Where part of the larynx can be saved, the risks of the operation will be greatly lessened. Lightly plug the wound with aseptic gauze, leaving the cannula *in situ* for twenty-four hours. The patient should lie with his head low and on one side, and should be fed at first through a soft tube passed down the œsophagus, and by nutrient enemata. On the healing of the wound an artificial larynx, if the whole organ has been removed, may be fitted to the parts, by the help of which the patient will be able to speak moderately distinctly.

DISEASES OF THE CHEST-WALL.

Caries and necrosis of the sternum and ribs may be traumatic, syphilitic, tuberculous, actinomycotic, or pyæmic, or may follow typhoid fever.

Gummata occur over the sternum or ribs, spreading over the clavicle, and give rise to induration and pain, especially at night. The skin becomes dusky red, the gumma softens and an ulcer forms, beneath which there is necrosis of bone. A gumma has to be diagnosed from aneurysm perforating the chest-wall, tubercle, actinomycosis and new growths. From an aneurysm it may be known by the absence of pulsation and bruit. Improvement under antisyphilitic treatment will confirm the view as to the character of the disease.

Tuberculous disease may cause a cold abscess, especially over the junction of the sternum and ribs, in children and young adults. This must be distinguished from a localised empyema pointing forwards between the ribs. *Treatment.*—Incision and removal of carious and cheesy bone and cartilage, the cavity being then filled with gauze.

Retrosternal abscess or abscess in the anterior mediastinum may be due to tuberculous caries of the back of the sternum, to necrosis from injury or other causes, to acute osteomyelitis of the sternum (the most dangerous form), to the breaking-down of tuberculous glands and gummata, to suppurating cysts in the remains of the thymus gland, and to septic extension from the neck.

Symptoms.—There is fever with pain, œdema, and later fluctuation in the episternal notch, in an intercostal space or over the sternum itself. There may be also dyspnœa and venous congestion in the neck. The special signs of aneurysm are absent, which affection, as well as retrosternal goitre, does not give rise to inflammation. *Treatment.*—The overlying sternum is carefully removed by gouge, chisel or trephine. The removal may be begun on one or other side, or by deepening the episternal notch until the cavity can be cleared out and gently filled with gauze. The greatest care must be taken not to injure the pericardium or a large venous trunk.

Actinomycosis of the chest-wall is generally secondary to this

disease in the lung. Several bluish sinuses form in a mass of indurated tissue discharging pus containing the characteristic granules, and the chest-wall and pleura prove on exploration to be occupied by an extremely vascular granulation tissue similar to a suppurating sarcoma (see further under *Actinomycosis of the Lung*).

Tumours of the chest-wall.—*Sarcomas*, both primary and secondary, may grow from the sternum or ribs. Generally they are periosteal and may contain cartilage or bone, but a myeloid sarcoma may possibly spring from the interior of the sternum.

Metastatic carcinoma, or the direct extension of a cancer of the breast, may involve the chest-wall. In the former case the sternum may be infiltrated and softened without being much altered in shape.

Tumours of the chest-wall are distinguished from intrathoracic growths by the breath sounds beneath being normal, and by the absence of pulsation and of an impulse on cough. They must also be distinguished from the diseases described above, namely, syphilis, tubercle and actinomycosis. It is only exceptionally that success is likely to follow removal, unless in the case of a myeloid sarcoma. The extent of the tumour must first be ascertained by opening the pleural cavity and exploring the inner aspect, when the whole thickness of the chest-wall may be cut away, including the tumour, and the hole filled with gauze (see *Resection of Ribs for Empyema*). The only tumour suitable for shelling out would be a myeloid sarcoma.

Subpleural lipomata are occasionally met with. They spring from the external layers of the pleura, and perforate the intercostal muscles, retaining their attachment to the pleura by a peduncle. They should be removed and the peduncle ligatured. They cannot be easily diagnosed from a cold abscess by palpation.

Aspiration of the pleural cavity.—*Aspiration* may be required for diagnosis or relief of pressure. For *diagnosis* an exhausting syringe with a long strong needle of not too fine a bore is inserted through the seventh or eighth interspace in the post-scapular line for about two inches, unless there is some reason for exploring above and in front. The cavity, if small, is more likely to be reached at that point; above and in front the needle may enter the lung, pericardium or pleural adhesions, and below, the diaphragm. The needle should be sharp pointed and be pushed in smartly so as to pierce thickened pleura and the point should be then moved a little to prove that a cavity has been entered. Serous and hydatid fluid, also thin pus may be drawn off; if only a little is obtained, this may be proved under the microscope to contain inflammatory or pus cells or organisms, or a stab culture inoculated by the needle may show a growth. The needle may not draw off fluid because it has become blocked by fibrin or the pus is too thick, or the point has entered a spongy mass of fibrin, or the wall of a loculus, when a second

attempt may yield more information; or the fact that the needle enters a more solid material than lung, from which only blood is drawn, may point to a tumour or actinomycosis. *A pleural effusion* should be drawn off with the aspirating bottle and syringe, the skin being well prepared and carbolic acid drawn through the needle beforehand, the working of the syringe and cocks and the formation of a vacuum in the bottle tested. The patient is sitting, leaning forward and supported, and the trocar and cannula inserted as described above for the aspirating syringe. The fluid should be allowed to escape slowly to avoid distress and cough, and when it ceases to flow, the needle is quickly withdrawn without relaxing the exhaustion and the puncture covered with a collodion dressing.

Serous straw-coloured fluid, turbid fluid, hydatid fluid, air and thin pus may be thus drawn off. If the fluid is hydatid, *i.e.*, clear, uncoloured, free from albumin, therefore not frothing easily, and having the other characteristics (see p. 164); aspiration should immediately be stopped for fear of fatal pulmonary œdema, and the operation for an hydatid cyst at once proceeded with. If the fluid is purulent or sero-purulent, there is no object in continuing the aspiration, since the sooner an incision is made the better, except in tuberculous cases when the patient is dying from pulmonary phthisis. Aspiration of blood in hæmothorax and of air in pneumothorax may relieve.

A serous effusion may have to be tapped several times, especial care being taken each time to avoid septic infection; increasing turbidity due to leucocytes indicates the onset of suppuration. If after several tappings no advance in expansion of the lung is found, although the fluid still remains simply serous, the chest should be drained.

Operation for empyema thoracis.—An empyema thoracis, like other collections of pus, requires surgical treatment at the earliest possible moment by such a free incision that all the contents are forthwith removed, and that no re-collections, however temporarily, occur to check healing or the recovery of the patient from the effects of the previous septic absorption. The healing is similar to that of other abscess cavities, namely, by the falling-in of the walls, which become lined by healthy granulations, ultimately changing into fibrous tissue. Union by second intention then occurs between the pleural surfaces, ending at the line of incision.

The common form of non-traumatic empyema seen formerly was described as containing creamy pus of a sweetish odour, without much change in the pleural surfaces, so that after its removal the lung expanded freely and at once. Nowadays, especially in connection with influenza, and probably as the result of a pneumococcus infection, the empyema is of a fibrinous character, the pus forming in the meshes of a spongy mass of fibrin, which

cannot escape through a small incision, whilst both the visceral and parietal pleura are much infiltrated and rendered rigid by the fibrinous exudation, so that expansion of the lung is not so spontaneous. Besides the pneumococcus, many other (some twenty) organisms have been found in empyemata. A streptococcus empyema may be attended by marked œdema of the chest-wall, and when combined with pneumonia is of very unfavourable prognosis. Tuberculous empyema causes a marked thickening of the pleura, also caries of ribs, and may occur even when the lungs are not already broken down into tuberculous cavities. Empyema may also result from actinomycosis of the lung extending outwards to the pleura and chest-wall. The great vascularity of the tissue in these cases prevents any further measure than a cautious attempt to reach retained pus. But the prognosis is bad, since extension may go on from the chest-wall to the spine. An empyema, further, may be associated with pneumonia, broncho-pneumonia, or gangrene of the lung. In the last instance the pus is mixed with stinking gas from the presence of a gas-forming bacillus belonging to the colon-bacillus group. By very early incision and removal of the sloughing lung, the patient may be saved, supposing always the condition to be limited. *Operation.*—The patient, having more or less dyspnœa, it is essential that only a very little anæsthetic, especially if chloroform is used, should be given until some of the fluid has been let out. From non-observance of this rule sudden death has often been reported, although in severe orthopnœa we have not seen any harm from a little gas followed by ether, or a few whiffs of ~~A.C.E.~~ Still the surgeon should stand by ready to rapidly cut into the chest immediately that the combination of the anæsthetic and the previous cyanosis has produced sufficient analgesia. Should the breathing stop, the fluid should forthwith be let out, before beginning artificial respiration. If some of the pus can be drawn off through an aspirator, this may be done before the anæsthetic is given, and is especially important in the rare instances of a bilateral effusion. The patient is turned to the opposite side and the arm of the same side held up. If brought to the edge of a high table this turning can be largely avoided; if on a low table or bed, the patient may be turned nearly on to the face, as then the back part of the sound lung will be able to expand (Godlee).

The line of incision should, as a rule, be made over the seventh or eighth rib in the post-scapular line. This incision will generally be over the most dependent part of the cavity, and will thus avoid a counter-opening having to be made, whilst the removal of a rib in this position has a good effect in letting the chest-wall fall in. If the incision is made lower the diaphragm may be wounded, or this muscle may subsequently rise up as the pus is let out and narrow or block the opening. Moreover, an empyema does not often extend below the eighth or ninth ribs, the lower pleural

cavity being shut off by adhesions. To open the chest anteriorly is likely to necessitate a counter-opening. The incision should be made directly over the rib dividing the periosteum, which is rapidly separated from the bone in front and behind for 1½ inch by a raspatory, and the exposed piece of rib cut out with bone-forceps. A horizontal incision is next made through the parietal pleura, avoiding the intercostal vessels, or forceps are thrust in. If the pleura is much thickened an incision is necessary, or the forceps may push it inwards before them. All this should be done as rapidly as possible; the bleeding, if it does not spontaneously cease, is attended to later. A little pus being let out, more of the anæsthetic may be safely given. Then with a sponge on a holder, with forceps or with the finger, fibrinous masses and blood-clot should be detached and drawn out, loculi broken down, and the margin of the collapsed lung freed to encourage its expansion, which takes place during expiration and cough. When the cavity has been wiped out clean, the lung often expands almost completely, or it may be proper to separate freely its adhesions, and to remove a piece from the ribs immediately above and below the incision, or owing to the weakness of the patient to postpone this to a second operation. The cavity being wiped out when foul with an antiseptic, a strip of iodoform gauze is inserted, and the chest dressed and bandaged, but not tightly. The gauze checks oozing and favours the development of granulations, whilst air cannot be sucked in during inspiration. The mere insertion of a drain tube through a small incision is not so advantageous, since unless the incision is large the cavity cannot be cleared of septic material, and air tends to rush in through the tube during inspiration, introducing septic organisms and favouring collapse. Besides, if a tube is kept in long a sinus results. A piece of rib should always be removed to allow of a free opening and the treatment of the cavity as above described. It does not increase the severity of the operation or lead to further complications.

Thoracoplasty or Estlander's operation consists in removing a portion of several of the ribs, for the purpose of allowing the chest-walls to fall in, in cases of empyema where, after the pleura has been drained, the lung in consequence of adhesions does not expand. An incision three or four inches in length may be made obliquely downwards and inwards over the side of the chest, just in front of the latissimus dorsi, across the ribs the portions of which it is intended to excise. The edges of the wound being retracted to expose the ribs an incision is next made through the periosteum along the course of each rib for the required distance, the periosteum separated with a raspatory from both the outer and inner surface, and the rib then cut through with the saw or bone forceps at each end of the incision, the soft parts being protected by a spatula passed beneath the rib. If the pleura is greatly thickened a portion

of the parietal layer may be cut away, after applying ligatures, and the visceral layer then scraped so that it may adhere to the skin and muscles in the flaps (*Schede's operation*). If the lung is bound down by the greatly thickened visceral pleura this may be dissected off so as to allow the lung to expand (*pulmonary decortication*). It is often wise not to do too much on one occasion. The result is a falling-in of the chest-wall to meet the lung. A tendency to lateral curvature of the spine must be prevented by muscular exercises. Failing a cure, hectic and amyloid disease, or pyæmia, causes the death of the patient.

Pneumotomy, or incising the lung, may be required for the purpose of opening an abscess or hydatid cyst, or of draining a gangrenous, phthisical, or bronchiectatic cavity, or for removing a foreign body. This may be done at two operations. An incision is made down to the pleura, a portion of the rib being excised ; if no adhesions exist the lung is then sewn to the pleura by stitches passed deeply by means of Hagedorn's needles. The wound is then plugged with iodoform gauze. After a few days, when adhesions have formed, a trocar and cannula connected with an aspirator is thrust into the cavity in the lung, the wound made by the cannula enlarged by dressing-forceps and a drain tube inserted. The patient should not be placed on his sound side during the operation lest the fluid, in the case of a cavity communicating with a bronchus, pass through the opposite main bronchus into his sound lung.

Pneumectomy, or excision of a portion of the lung for localised tubercle, has been successfuly accomplished in a few cases. The pleura is opened, for example by excision of a piece of the second rib in front to reach the apex, the collapsed lung transfixed below the disease with a blunt needle armed with aseptic silk, the silk tied, and the lung cut away above the ligatures. This operation is rarely indicated, since when the disease is sufficiently localised to permit of removal it is probably amenable to medical treatment. Excision of a portion of a lung for malignant growth, except when the growth invades the lung from the chest-wall, can seldom be required, in that primary malignant disease of the lung in a sufficiently early stage is seldom diagnosed.

Hydatid cyst of the pleura or surface of the lung.—It is most dangerous to empty an hydatid cyst by aspiration, as fatal pulmonary œdema may set in. As soon as the hydatid nature of the fluid is recognised the aspiration should be stopped, and removal at once proceeded with by incising the adventitious and removing the parasitic cyst. The lung may now readily expand, or the adhesions of the adventitious cyst may be separated, or the cavity treated like an empyema.

Aspiration of a pericardial effusion.—When there is a large serous effusion, the puncture, according to Dr. West, should be made in the left nipple line, or immediately to the left of the

sternum, or even to the right of the sternum. The internal mammary and intercostal vessels should be avoided, and the needle not thrust deep enough to enter the heart or left pleura.

Incision and drainage of the pericardium.—To incise and drain the pericardium a flap of skin may be turned up and the left fourth and fifth rib cartilages, one or both, excised. Or a quadrilateral flap composed of the skin and ends of the ribs may be raised together and turned inwards over the sternum. The internal mammary must be secured at each end as it runs downwards on the triangularis sterni about half-an-inch from the sternal border. The pericardium is now recognised as an opaque, shiny white membrane, the fold of the left pleura as pinkish, translucent, bordered by fat. The pericardium is carefully opened, avoiding the pleura, and the pus evacuated by gentle wiping and syringing, especially from the dependent pocket behind the heart, into which a tube is passed. The auricles lie behind the third and fourth ribs, the ventricles behind the fourth and fifth. Thickened pericardium may partly be cut away. Sometimes the pericardium may be distended downwards towards the space between the xiphoid cartilage and rib border, when the sixth rib cartilage may be removed without fear of opening the abdomen. When an empyema pericardii co-exists with a left empyema the former has been reached from and drained through the incision for the latter.

Posterior mediastinal abscess is due to suppuration in bronchial and posterior mediastinal glands. The abscess may form a thoracic empyema, or may burst into the œsophagus or trachea with flooding of the lungs, or into a large blood-vessel. Or tracking down, it may appear below the last rib, and may break externally, resulting in a long-standing sinus. Spencer has cured two such cases, one tuberculous, the other dating from an attack of influenza. In both, the sinus was followed up to the seventh and eighth rib respectively, by cutting through their necks, without opening the pleura.

DISEASES OF THE ŒSOPHAGUS.

Hæmorrhage from the œsophagus is distinguished from hæmatemesis by the alkalinity of the blood. It generally indicates a leaking aneurysm or a malignant ulceration, less often a varicosity of œsophageal veins, dilated by the anastomosing circulation following upon cirrhosis of the liver. The patient is kept at absolute rest on nutrient and fluid enemata, nothing being given by the mouth. But the prognosis is bad.

Perforation of the œsophagus may be caused by a prevertebral abscess or empyema thoracis bursting into it, or it may be due, especially in children, to a caseating lymphatic gland. The treatment is similar to that described for hæmorrhage.

Pouches of the œsophagus are occasionally met with. They

nearly always arise from the back of the tube and near its junction with the pharynx, and as they increase in size, bulge in the neck on one or both sides of the cricoid cartilage. The *symptoms* to which they give rise are regurgitation of undigested food some hours after it has been taken, and difficulty in swallowing, but no wasting or loss of weight for many years, indeed not until the last stages of the disease. A bougie or sound can at times be passed into the pouch from the mouth, a resistance being then met with about nine inches from the upper incisor teeth. A second bougie may then also at times be got past the pouch into the stomach, and the two bougies can be shown up by *x* rays. At times the pouch can be felt in the neck, and food can be squeezed out of it into the œsophagus, the pouch becoming flaccid. The *treatment* consists in removing the pouch through an incision in the neck behind the sterno-mastoid, closing the wound in the œsophagus with sutures and plugging the superficial wound.

Compression of the œsophagus may be caused by a simple or malignant bronchocele, malignant disease of the larynx, or by enlarged lymphatic glands; in the thorax by an aneurysm, mediastinal tumour, or by pleural and pericardial effusion. But cancer is by far the most probable cause of obstruction in all obscure cases.

Stricture of the œsophagus may be due to spasm of the muscular fibres (*spasmodic stricture*), to cicatricial contraction (*fibrous stricture*), or to epitheliomatous or other malignant growths of its walls (*malignant stricture.*) It may be simulated by compression of the œsophagus from without (see *Compression*).

Spasmodic stricture or *spasm of the œsophagus* generally occurs in young hysterical women. The patient may be quite unable to swallow, and a bougie, perhaps, will not pass, or only after gentle pressure has been kept up for some time. The *diagnosis* from other forms of obstruction will then rest on the obstruction existing only at times; on the age and sex of the patient—œsophageal cancer being exceedingly rare in a woman; the presence of other signs of hysteria; but chiefly on the fact that, under an anæsthetic, the bougie, which could not previously be passed, or only with difficulty, slips down easily into the stomach. The *treatment* should consist in the administration of anti-hysterical remedies; whilst the patient may be persuaded that the bougie has cleared the passage.

Fibrous stricture is generally due to cicatricial contraction following any injury, as swallowing boiling water or corrosive fluids, or the impaction of a foreign body. More rarely it results from the healing of a syphilitic ulcer. At times it is congenital, and is then situated opposite the bifurcation of the trachea. Indeed, some children are born not only with a constriction, but with a fistulous communication with the trachea at this spot. Sometimes no cause can be discovered. It may exist at any part of the tube, but is

most common in the upper half (Fig. 404). It is much rarer than the malignant form, but is liable to become malignant when it has existed for some time. As the result of the constriction the tube above the stricture becomes dilated and the muscular coat hypertrophied. The dilatation may be general or pouch-like, in the latter case consisting either of a dilatation of all the coats, or of a hernia of the mucous membrane through the muscular fibres.

Malignant stricture is generally epitheliomatous, and nearly always occurs in men. It may be met with at any part of the œsophagus, but is most common opposite the cricoid cartilage, at the bifurcation of the trachea, and at the cardiac end of the stomach (Fig. 405), situations at which normally slight obstruction to a bolus of food larger than usual exists, and at which

Fig. 404.—Fibrous stricture of œsophagus at region of cricoid cartilage. (St. Bartholomew's Hospital Museum.)

Fig. 405.—Malignant stricture of œsophagus at entrance of stomach. (St. Bartholomew's Hospital Museum.)

"developmental processes are complicated, and where, therefore, errors of nutrition are more likely to occur." Thus, at the cardiac orifice the epithelium changes its character; and where the œsophagus is crossed by the left bronchus, the food and air passages were originally one. Epithelioma may begin as a distinct cauliflower-like excrescence springing from one side of the tube; or as a nodular induration of the mucous membrane involving ring-like the whole calibre of the œsophagus. It gradually encroaches upon the lumen of the tube, causing more or less complete obstruction. The growth sooner or later ulcerates, and invades the surrounding tissues, the mediastinum, pleura and glands; and sinuses may form between the œsophagus and the trachea or left bronchus, or open externally when the disease is high up in the neck. The patient, if he does not die of starvation, succumbs to pain or exhaustion, or to hæmorrhage from the

laying open of a large vessel, or to abductor paralysis or to pleurisy or pneumonia.

The *symptoms*, common to both the fibrous and malignant stricture, are—1, increasing difficulty of swallowing, first of solids, then of liquids, and finally inability to swallow either; 2, a feeling of obstruction, generally referred to the top of the sternum, and craning movement of the neck in attempting to swallow; 3, regurgitation of food after it has been swallowed for a short time (where the stricture is low down or pouch-like dilatations have formed); 4, a trickling sound on auscultation between the shoulders whilst the patient is swallowing fluid; and 5, progressive wasting and loss of strength. Malignant disease may go on for a long while and even give rise to a secondary epitheliomatous tumour before being discovered. In some patients the first signs are those of dyspepsia, or hæmorrhage, or laryngeal paralysis, paralysis of the sympathetic, gangrene of the lungs, empyema, or pyopneumothorax, or even the formation of a mass of enlarged glands in the lower part of the neck.

The *diagnosis*, however, can only be made with certainty, and the situation of the stricture ascertained, by the passage of a bougie. But before attempting to pass a bougie, a careful examination of the chest should be made for the purpose of excluding aneurysm as a cause of the symptoms, lest such should be ruptured, as has before now happened. The diagnosis of the malignant from the fibrous stricture will rest on the advanced age of the patient, the absence of any discoverable injury, the presence of blood or foul-smelling discharge on the end of the bougie, a sensation of passing over an ulcerated surface, and the presence of enlarged glands in the neck or of an indurated mass in the situation of the tube when the stricture occurs in the neck. A mass of large glands in the lower part of the neck in an old man should always arouse a suspicion of malignant disease of the œsophagus.

Treatment.—In the *fibrous form* the stricture should be gradually dilated by bougies, a bougie being passed twice a week, and the patient fed in the intervals with concentrated liquid food. When the stricture is very tight great care must be taken lest the bougie perforate a pouch above the stricture. When the smallest sized bougie will not pass, a long catgut bougie may sometimes be insinuated by telling the patient to swallow whilst the catgut is pushed on, and over this a larger catheter, open at the end, may then be passed. When the stricture is very resilient its division posteriorly in the middle line has been tried (*internal œsophagotomy*), but it is a risky procedure, and should only be done when the stricture is in the upper part of the œsophagus. When the stricture is impermeable even to catgut, especially when it is near the lower end of the tube, gastrotomy may be done and an endeavour made to pass a bougie upwards. This will often be successful, as there is no pouch below the stricture in which the end of the bougie can

become engaged. The stricture may be in this way rapidly dilated with bougies, or a bougie may be passed up into the mouth, a piece of string attached to its end and drawn with the bougie out through the stomach wound. By see-sawing on the ends of the string the œsophageal stricture can be readily divided. Failing to dilate or divide the stricture, the stomach wound may be left open and the patient fed through the gastric fistula. The rest thus given to the parts may enable the stricture to be successfully dilated on a subsequent occasion. When the stricture is situated at the cardiac end, and a well-directed trial at dilatation has failed, gastrotomy may be performed, and the stricture forcibly dilated by the finger from the interior of the stomach. If the stricture cannot be dilated

Fig. 406.—Method of placing a Symonds' tube in an œsophageal stricture.

by any of the means above mentioned a permanent gastric fistula must be established.

In *malignant stricture* dilatation by bougies or tubes, in the way recommended in fibrous stricture, must not be attempted, as the walls of the œsophagus are so softened by the ulceration and disease that great danger of perforation and extravasation into the mediastinum or pleura would be incurred. The œsophagus should be given as much rest as possible by eliminating all irritating substances from the diet. The patient should be fed on strong soups, minced meat, milk as long as he can swallow, cocain and morphia lozenges or ice being given to him to suck before each meal to reduce the spasm. Iodide of potassium in small doses may also be administered for a like purpose for a little while. Opium also relieves spasm and pain, and may be given, first at night and then during the day in increasing doses. If an attack of extra difficulty in swallowing

comes on, the œsophagus may be put to rest for a few days by resorting to nutrient enemata. In some cases where the cancer is well below the larynx and well above the cardiac end a Symonds' tube (Fig. 406) may be passed through the stricture by means of a suitable holder, and left *in situ* attached by a strong string which is secured to the cheek or ear by strapping. Care must be taken that the patient does not swallow the string. Should this accident happen during the treatment, an attempt may be made to recover the tube by forceps, etc., or this failing, to push it into the stomach whence it may pass onwards or be removed by gastrotomy. Excellent results have followed the use of these tubes, especially when the cancer is in the middle of the œsophagus; patients have regained flesh, have fairly enjoyed life for some months, and have then died in comparative ease. On the other hand, the tube sometimes causes so much irritation that it cannot be borne. When a tube cannot be passed, or is not tolerated, gastrostomy may be performed, or the œsophagus, if the disease is high in the neck, may be opened below the stricture. If gastrostomy is to be of service, it should be undertaken before the patient has been so reduced by semi-starvation that he has not strength to bear the operation. Œsophagotomy is practically of no service, since the cancer soon invades the wound and the last state of the patient is worse than the first. Of late years one of us (Walsham) has abandoned all the above-mentioned methods, as in his experience they only increase the rapidity of the growth and accelerate the fatal issue, besides causing great irritation to the patient. He now, as soon as the diagnosis is made, resorts at once to gastrostomy. By this means the rate of growth is checked, and the patient puts on flesh, and after a few weeks suffers very little inconvenience from the stomach feeding. The gastrostomy tube is brought out through a convenient hole in the dress by which it can be easily concealed and properly clamped to prevent regurgitation, and into it a funnel can be readily inserted for feeding purposes without the inconvenience of undressing.

SURGERY OF THE ABDOMEN.

SURGERY OF THE STOMACH.

Washing out the stomach.—A soft rubber œsophageal tube is passed into the stomach and connected with a length of rubber tube and a funnel. After the stomach has been filled with hot water or boric lotion the funnel is lowered, the tube forms a syphon, and the fluid flows out. Washing out the stomach may be required (1) in cases of poisoning, (2) to remove the undigested remains of a meal in pyloric obstruction, (3) to prepare the stomach for an operation involving its walls, (4) to relieve fæcal vomiting in intestinal obstruction, and to prevent the regurgitation of fæcal matter

whilst the patient is being anæsthetised, (5) to obtain the contents for chemical examination, and (6) to ascertain whether there is gastric stasis, *i.e.*, whether food is retained for too long a period in the stomach owing to pyloric obstruction. A test meal, *i.e.*, a meal of known quantity, is given, and after five hours the stomach is washed out. In health, the meal should have practically disappeared. The process of washing out is often resisted by the patient,

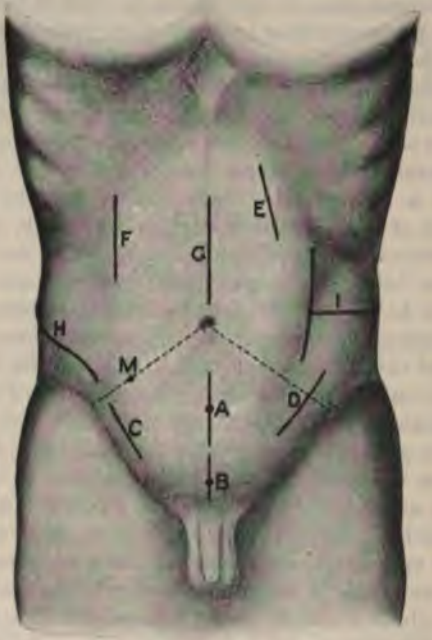

FIG. 407.—Lines of abdominal incisions. A, Median incision for laparotomy, ovariotomy, etc.; the dot for tapping ascites. B, Suprapubic incision for cystotomy; the dot for tapping the bladder. C, Inguinal incision for hernia. D, Iliac incision for colotomy, for the appendix and cæcum on the right side, and for ligature of the external iliac outside the peritoneum. E, Left hypochondriac incision for gastrostomy. F, Right hypochondriac incision for the gall-bladder and liver. H, Oblique lumbar incision for nephrotomy. I, T-shaped lumbar incision for nephrectomy; M, McBurney's point.

although the irritation of the back wall of the pharynx may be prevented by painting or spraying with cocain. Moreover, in exhausted patients it causes much shock. To avoid washing out, therefore, (*a*) in fæcal vomiting from intestinal obstruction the patient may be given as much warm water as he can swallow, which will either flush out the stomach through the pylorus or be returned by vomiting; (*b*) before an operation upon the stomach, the patient may be placed on nutrient enemata, and be kept entirely without

food by the mouth for twelve hours; then the naturally antiseptic action of the hydrochloric acid of the gastric juice has time to render the interior aseptic. Elaborate methods are used for examining the gastric contents, but as regards the early stages of cancer, when alone it is removable, the results are untrustworthy. In cancer the hydrochloric acid of the gastric juice is never increased in amount, and may be markedly diminished, while at the same time lactic acid is present in inverse proportion. The diminution in the amount of hydrochloric acid only occurs, however, when the mucous membrane and glands have undergone atrophy, owing to the long duration of the disease. In chronic dyspepsia and ulceration the hydrochloric acid may be increased.

Gastrotomy or incision of the stomach is employed for the removal of foreign bodies, the exploration of the interior of the stomach, and the dilatation through the stomach of its pyloric and cardiac orifices (see p. 832).

Gastrostomy is the establishment by operation of a fistula, leading from the skin into the stomach for the purpose of feeding the patient. The operation should be planned in such a manner as to ensure (*a*) that the already exhausted patient may be fed forthwith without danger of peritonitis setting in from extravasation of the food. It is further necessary to (*b*) prevent the leakage of gastric juice, which in the early stage dissolves the adhesion between the stomach and the abdominal wall; and (*c*) to avoid, at a later period, the prolapse of the mucous membrane and the troublesome eczema of the skin which may be set up around. Moreover, owing to the half-starved condition of the patient, the stomach will be found shrunk up under the left margin of the ribs, and considerable difficulty may be experienced in drawing it into the wound.

Most surgeons now adopt the same incision through the abdominal wall, though there are various methods of fixing the stomach. An oblique skin incision, one inch below and parallel to the left border of the ribs, is selected as the nearest point to the shrunken and retracted stomach. It is made for two or three inches, commencing about one and a half inch from the middle line. The sheath of the rectus muscle is then opened vertically, and the muscular fibres separated, not cut, in order to prevent a hernia and prolapse of the stomach, the sphincter-like action helping to check the escape of gastric juice. The posterior layer of the sheath is next divided horizontally, as this gives room for finding and drawing up the stomach, whilst the wounds in the several layers are all three in different directions. Bleeding is stopped and a small hole made into the peritoneum. The stomach is sought for below the left ribs and beneath the liver. If the fingers are passed backwards along the under surface of the left lobe, the stomach must be reached. The transverse colon will most probably present, and will be recognised by its longitudinal fibrous bands, its encircling vessels and appendices

epiploicæ, whilst the stomach will be known by its thick, smooth, and pinkish-red coats, and by the leash of large vessels seen along its upper and lower borders. The stomach is gently drawn forwards so as to reach a point as near to the cardiac orifice and as far from

Fig. 408.—Howse's method of suture in gastrostomy.

the pylorus as possible. The subsequent steps of the operation will now differ according to the method employed. 1. *Howse's method by two stages.*—Two loops of silk are passed through the peritoneal and muscular coat for the purpose of securing a good hold of the

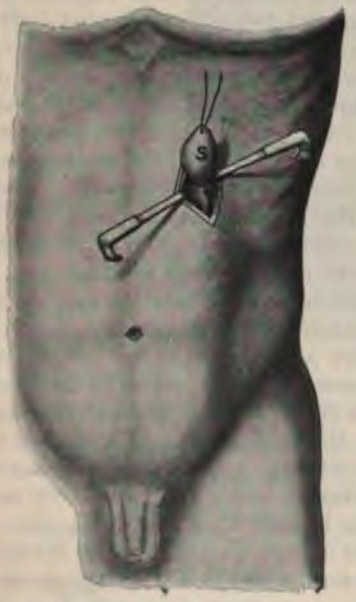

Fig. 409.—Franks' method of gastrostomy.

Fig. 410.—Franks' method of gastrostomy.

stomach whilst the sutures are being introduced, and also for the purpose of steadying it during the subsequent operation of opening it and thus preventing the risk of the adhesions being broken down. The stomach, as near the cardiac end as possible, is now stitched to

the parietes by a double ring of sutures, so as to ensure a good inch of the stomach-wall (that between the outer and inner ring of sutures) being in contact with the parietal peritoneum (Fig. 408). The outer ring of sutures is passed first, by carrying the needle, armed with a silk suture, through the serous and muscular coat of the stomach and the abdominal parietes, a good inch from the edge of the wound. The inner ring of sutures are then passed through the serous and muscular coat of the stomach and the skin and peritoneum of the parietes, and tied. The wound is dressed antiseptically. At the end of from four to six days the stomach will generally be found adherent, and should then be punctured with a long sharp tenotomy knife, while it is drawn well forwards by the silk ligatures

FIG. 411.—Witzel's method of gastrostomy. (After Meyer.)

FIG. 412.—Witzel's method of gastrostomy. (After Meyer.)

left in for the purpose. A No. 6 or 8 English catheter is passed through the puncture, and the wound again dressed antiseptically, the catheter projecting through the antiseptic dressings. At first only teaspoonfuls at a time of fluid nourishment should be given; later a tube may be passed at meals, and minced food introduced.

2. *Franks' method.*—A conical portion of the stomach is drawn into the wound (Fig. 409, s) and the base of the cone is fixed to the parietal peritoneum by suture so as to cut off the peritoneal cavity. A second incision three-quarters of an inch in length is next made above the rib-margins through the skin only. The bridge of the skin "between the two incisions is undermined," and the apex of the stomach pulled under it and out of the second wound. The stomach is at once opened and stitched to the skin and the first wound closed. In this way a valvular opening is obtained, and the

patient can be fed at once. It is somewhat difficult to drag the stomach, if much contracted, under the bridge into the second wound. Moreover, the stomach opening may retract and set up subcutaneous septic emphysema, or so drag and prevent movement that anything but a small meal causes pain, or it may gradually become a direct opening and leak, the amount of leakage being only limited by the narrowness of the orifice, which is then correspondingly difficult to feed through. Such are some of the objections that have been raised to this method, but one of us (Walsham) has not met with them, although he has frequently employed it. 3. *Witzel's method* is useful when the stomach is small and contracted and cannot be drawn into the wound. Witzel makes a small opening into it just sufficient to admit a rubber tube about the size of a No. 8 catheter (Fig. 411). Two vertical folds of the stomach are next secured by a number of Lembert sutures well over the tube for a distance of about two inches; the gastric end of the tube is thus buried, so as to prevent any regurgitation backwards or sideways (Fig. 412); the distal end of the tube is then brought out through the upper part of the wound in the parietes to which the stomach is firmly fixed by sutures; the rest of the wound is then closed (Fig. 413). Here also a valvular passage is made through the coats of the stomach, and the patient can be fed through the tube at once. 4. *Kader* or *Senn's method* consists in drawing a cone of the anterior wall of the stomach into the wound, fixing a glass cannula through a hole made in the apex, and then inverting the apex into the interior of the cone. The opening into the stomach will thus be situated at the bottom of the funnel formed by the inversion of the apex of the cone. The cannula, provided with a flange to prevent it slipping out, is fixed by tightening a purse-string suture running in and out the stomach walls (Fig. 206, a), and the inversion of the cone maintained by a second suture inserted in a similar way. The stomach is then sutured to the peritoneum only, so as to allow of freer peristaltic movements. If it is much contracted and cannot be

FIG. 413.—Witzel's method of gastrostomy. (After Meyer.)

drawn into the wound, the parietal peritoneum may be separated around for an inch or more from the muscles, so that it may be carried down to meet the stomach, and gauze packed around the cannula. A rubber tube, with a funnel, is attached to the cannula.

This is an excellent method. The patient can be fed from the first—half a pint; later, a pint at a time—without causing pain from limitation of the peristalsis. The cannula holds without leaking for four to six days, so there is no danger of peritonitis. When loose it is replaced by a rubber catheter, which, as soon as the fistula is established, can be left out between meals. The inversion effectually prevents any leakage of gastric juice, and the patient can soon feed himself.

It often happens, after gastrostomy has given rest to the œsophagus, that the patient finds himself able to swallow. The thorough mastication and swallowing of small quantities will tend to prevent him suffering from anorexia.

The surgery of gastric ulceration.—1. A gastric ulcer may rapidly perforate into the peritoneal cavity. 2. It may slowly leak, especially into the lesser peritoneal cavity, and cause a subphrenic abscess. 3. It may set up spasm or stricture of the pylorus, causing an arrest of digestion or gastric stasis followed by dilatation of the cavity. 4. It may give rise to repeated hæmorrhages. 5. It may cause the stomach to become fixed by adhesions, producing dragging pains; or (6) it may lead to localised contraction of the stomach, forming an hour-glass or bilocular constriction. All these conditions may be treated surgically.

1. *Acute perforation.*—The characteristic sign of perforation is a sudden acute agonising pain in the epigastrium accompanied by collapse. Generally symptoms of chronic gastric ulceration have occurred previously, yet there are latent ulcers of which perforation is the first sign. The pain may be marked and continuous, or a period of calm may intervene before peritonitis sets in. The collapse may be very severe up to unconsciousness, with a subnormal temperature and slow, feeble pulse, or it may be only a transitory faintness. Vomiting is not usual; it may occur once and then not reappear till peritonitis excites it. The abdomen is at first retracted and hard; then distension commences—first in the epigastrium, which becomes tympanitic. With this the liver dulness may disappear, but this sign is subject to much variation, apparently in connection with distension of the colon. The respirations are short and thoracic, and the pulse gradually increases in frequency. Later on, all the signs of acute septic peritonitis set in. It is better to make an exploratory incision at once, since if the surgeon waits for the diagnosis to be confirmed, peritonitis which may end fatally may, in the meantime, be set up. Similar signs may attend perforation of the duodenum, intestine, or vermiform

appendix, and it may be only on opening the abdomen that the perforation can be located. If, therefore, the stomach is found intact the search should be extended to the other viscera named.

Treatment.—The abdomen should be opened in the middle line above the umbilicus; the perforation, which is usually quite small, clean cut, and situated upon the anterior surface of the stomach, sought, tucked inwards (Fig. 414), and the peritoneal coats brought into contact over the perforation by a double row of Lembert's sutures (Fig. 207). If little soiling of the peritoneum has taken place, the area of extravasation only should be sponged clean and the wound closed; but if extensive extravasation has occurred, the peritoneal cavity should be well flushed out, and a gauze drain placed in the wound and in counter-openings in the loins and above

Fig. 414.—A stomach opened to show the puckering of the mucous membrane after suture for perforating ulcer. (St. Bartholomew's Hospital Museum, No. 1918 a^1.)

the pubes. Some advise that a portion of the stomach wall around the hole should be excised, and a continuous suture placed in the mucous membrane, and a second row of Lembert's sutures in the peritoneal and muscular coats. This, however, is generally not necessary nor advisable. In many cases it is doubtful if suture of the mucous membrane be possible. When the perforation is surrounded by induration, especially when it is near the pyloric or cardiac orifice, it is difficult or impossible to invaginate, and dangerous to excise. In such cases the hole may be filled by a piece of omentum, which becomes firmly united and forms a plug. When far up under the ribs near the cardiac orifice a long strip of iodoform gauze should be packed in the peritoneum to form a drainage tract from the ulcer to the external wound, and withdrawn a little at each daily dressing.

2. *Subphrenic or perigastric abscess.*—An ulcer on the posterior wall may slowly leak into the lesser peritoneal cavity, and if the

foramen of Winslow is closed the inflammation may remain limited and a localised abscess form. Less often the leakage occurs in front, and then adhesion of the colon and omentum to the abdominal wall may also cut off the inflammation from the general peritoneal cavity. A subphrenic abscess generally bulges forwards above the lesser curvature of the stomach or extends to the left towards the region of the spleen or left kidney pouch, rarely to the right in front of the liver. It pushes up the diaphragm and may then perforate that muscle, extend into the pleura or into the left lung and cause an empyema, or into the pericardium and lead to fatal pericarditis. The chief sign in addition to the general evidence of

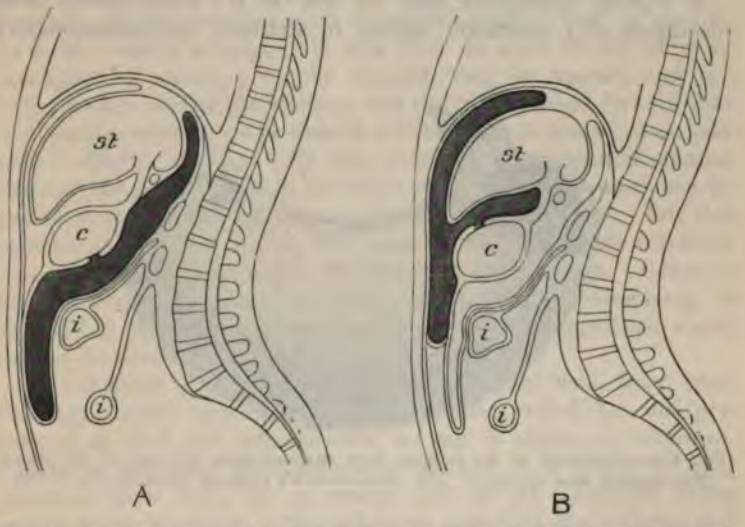

FIG. 415.—Perigastric or subphrenic abscess. A, posterior distending lesser omental cavity. B, anterior, localised in upper part of general peritoneal cavity.

suppuration is a tympanitic swelling bulging in the epigastrium or left hypochondrium, and encroaching on the thorax, but it is often impossible to say whether the encroachment on the left pleural cavity is due to the pushing up of the diaphragm or to the formation of a pyopneumothorax. But in the latter case the hyper-resonance extends to the summit of the thorax, whilst in the former, although there may be amphoric breathing or a bell sound below, yet the physical signs in the upper part of the chest are normal. A subphrenic abscess may not only be due to ulceration of the stomach or duodenum, but may also follow other septic abdominal infections, especially from the appendix and cæcum, from wounds or ulceration in other parts of the intestine including the rectum, from the liver or gall-bladder, spleen, pancreas, or kidney or pelvic organs, also from

empyema or from caries of the ribs. Maydl supposes that septic material gravitates upwards to the subphrenic region owing to the patient lying in bed, in the same way as a psoas abscess gravitates downwards because the patient is up and about. *Treatment.*—Aspiration is quite untrustworthy. A short vertical incision should be made immediately below the xiphoid cartilage in the middle line or just below the costal margin in the left linea semilunaris, and forceps or the finger thrust cautiously inwards. A simple drain may be all that is necessary, but at times a counter-opening may be required behind and to the left, through one of the lower intercostal spaces, or a pyopneumothorax may have to be drained after removing a piece of a rib.

3. *Pyloric obstruction* may be due to (i.) reflex spasm from ulceration, (ii.) ulceration ending in stricture, (iii.) inflammatory

FIG. 416.—Dilatation of the stomach from carcinomatous stricture of the pylorus. The stomach held ten pints. (St. Bartholomew's Hospital Museum, No. 1923 *a*.)

adhesions on the peritoneal aspect of the stomach, (iv.) kinking from dilatation and displacement of the stomach, (v.) malignant disease, and (vi.) in young children, congenital hypertrophy.

The *signs* of *simple* or *non-malignant* pyloric obstruction are delayed digestion or gastric stasis as shown by discomfort or pain following a meal and becoming worse, until after three or four hours there is vomiting of undigested food with relief. At the same time the stomach becomes more and more dilated (Fig. 416). The chief reasons for excluding malignant disease are the age of the patient (under thirty), chronicity of the symptoms, and the absence of a palpable pyloric tumour. The *surgical treatment* which should be resorted to when systematic washing out, diet and medical means have failed, and exhaustion and emaciation are increasing, consists in pyloroplasty, with or without gastroplication, or when this is impossible gastro-enterostomy.

4. *Hæmorrhage from an ulcer or gastrorrhagia* is not synonymous

with hæmatemesis, which may be due to causes other than ulceration. *Signs.*—The patient feels suddenly faint with a sensation of distension of the stomach by something warm, and then blood pours from the mouth with scarcely an effort. A pint or more of blood may be vomited and a large quantity may flow into the bowel and afterwards be passed per anum (*melæna*). The first hæmorrhage may be fatal or may lead to acute anæmia, from which the patient may slowly recover, or on the restoration of the pulse-tension a second or third and fatal hæmorrhage may occur. *Surgical treatment.*—Explorations have been undertaken for the purpose of arresting the hæmorrhage, but the outlook is not encouraging whilst the patient is in a state of acute anæmia. An exploration after the patient has somewhat recovered from the bleeding is more hopeful. When the ulcer is on the anterior wall it may be possible to tie the vessels supplying it, and then to tuck in the ulcer by sero-muscular sutures; or the stomach may be opened, and the finger passed behind the stomach and the ulcer pushed forward into the opening, when it can be cleared of débris—fruit stones, etc.—and seared with the cautery. By thus everting the mucous membrane through the wound, most of the inner surface of the stomach can be passed in review without opening the viscus very widely. But this measure if employed leaves the cause of the ulceration untreated and is therefore provocative of recurrent hæmorrhage. Hence in all grave cases gastro-enterostomy, or at least pyloroplasty, is required to abolish the gastric stasis and the decomposition which results therefrom.

5. *Adhesions of the stomach* to the abdominal wall, liver, gall-bladder, or colon may be caused by an ulcer, which has not perforated so that the inflammation set up is simple or adhesive. Persistent pain may be experienced, localised to a particular spot, which is made worse by movement and by the peristalsis which occurs during digestion. The adhesions may kink the pylorus and so induce pyloric obstruction, or press on the gall-duct and cause jaundice, or on the colon and set up constipation or intestinal obstruction. *Treatment.*—Exploration and the division of the adhesions has often been very successful in curing the patients. In addition, the ulcer causing the adhesions may require treatment.

6. *Hour-glass or bilocular stomach.*—The stomach is divided into two more or less unequal parts, (1) by perigastric adhesions, a cord passing from the liver to the abdominal wall or viscera below and pressing into the anterior wall of the stomach; (2) by the fixation of the stomach to the anterior abdominal wall as a result of ulceration, with or without perforation; (3) by constriction of the viscus due to the contraction following a circular ulceration, *i.e.*, in a direction transverse to the long axis of the stomach, somewhere about the junction of the pyloric third with the cardiac two-thirds, the contraction perhaps extending to such a

degree that the cardiac and pyloric portions only communicate by an orifice admitting a No. 3 or 4 catheter; (4) by a similar constriction, but the result of malignant disease which may or may not have been preceded by a simple ulceration. In this case the disease gradually spreads till it may involve the whole organ. The *symptoms* are generally those of chronic ulceration and dilatation. The special signs are those of the dilatation into two sacs, with an indurated mass between, also a gurgling sound due to the passage of fluid from one sac to the other; moreover, after washing out the cardiac sac until the fluid returns clear, if the patient is shifted to his left side, the decomposing contents of the

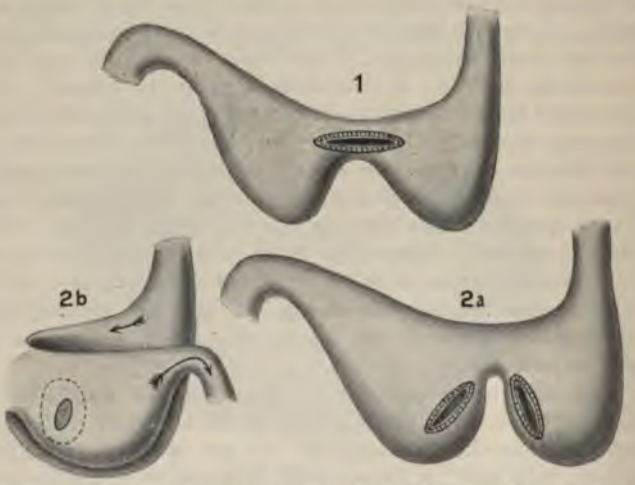

FIG. 417.—Hour-glass or bilocular stomach. 1. Treatment on the lines of pyloroplasty. 2. Treatment by anastomosis. 2 a, the two sacs opened, and 2 b, applied to one another by folding back the pyloric sac; but the stricture should be excised whenever possible.

pyloric sac may rush back into the cardiac sac, as evidenced on again washing out. The *operations* which have been employed are: (*a*) gastroplasty, or the division of the stricture as in pyloroplasty, which, however, is likely to be followed by a relapse; (*b*) gastro-gastrostomy, an anastomosis between the two sacs, which may not be easy to carry out, for the pyloric sac has to be brought back over the cardiac sac with the stricture as a hinge, so the disease may continue; (*c*) gastro-enterostomy, which seems to have been the least successful—indeed, a communication is then required between the jejunum and both sacs; (*d*) partial gastrectomy with end to end union, which as it gets rid of the disease is, if it can be carried out, the best operation, especially if there is any doubt of the disease becoming cancerous.

Carcinoma of the stomach.—This disease is of very frequent occurrence, causing the death of about 20 per cent. of all males dying of cancer in this country and 13 per cent. of all females. Although earlier and later ages are not exempt, yet it generally appears after forty and before sixty. Medical treatment has no means of checking the growth; and the amount of relief which can be given is very slight. The disease terminates fatally on an average in about a year from the commencement of the symptoms. It is very difficult, however, to diagnose it at such an early stage as to allow of removal by operation. A steadily increasing gastric disturbance occurring in a patient over forty should induce a most careful examination for signs of pyloric obstruction, such as gastric stasis and dilatation of the stomach, with or without a palpable pyloric tumour. If symptoms of obstruction however slight are present, an exploration with a view to excision of the disease must be advised at once. When the pylorus is first affected, as it is in the majority of cases, there is early gastric stasis, pain and distension after food, relieved by vomiting; and in patients where this occurs after forty a palpable tumour must not be waited for before advising exploration. It is useless to delay until there is marked wasting, hæmorrhage, vomiting of pieces of the growth, special organisms in the vomit: all these are late signs of cancer. That cancer supervened on chronic ulceration was formerly disregarded, by some physicians definitely discountenanced. But careful attention has shown that long-continued chronic ulceration and dyspepsia is not infrequently followed by cancer, which is a further reason for early surgical interference. 1. The *common form* of cancer of the stomach occurs as an ulcerating growth with surrounding infiltration, tending rapidly to glandular invasion, the glands involved being especially those along the lesser curvature up to the left coronary artery; also, but to a less extent, the glands of the greater curvature extending up to and behind the pylorus, between it and the head of the pancreas. The ulceration invades the stomach especially along its lesser curvature, and to a less extent along the greater, but is remarkable in that it hardly ever spreads to the duodenum. The induration first fixes it behind to the head of the pancreas, then to other structures, the abdominal wall, liver and gall-bladder. 2. A rarer form of cancer infiltrates all the wall of the stomach, forming a leathery puckered condition, compared to a leathern bottle. There is but little tendency to ulceration and a later infiltration around; also glandular enlargement takes place less quickly. 3. A still rarer form is a well-localised, sessile or pedunculated tumour, but such a tumour has often a sarcomatous rather than a carcinomatous structure, or may be in younger patients merely a fibroma. The *surgical treatment* consists in (1) local excision and suture, which can only be done in the rare third type; (2) partial gastrectomy, which must be more extensive than implied by the term pylorectomy;

(3) total gastrectomy, which has been done for the second, "leathern bottle" form; (4) gastro-enterostomy, when there is an inoperable growth about the pylorus but the cardiac end of the stomach is free; (5) jejunostomy, when the whole or nearly the whole of the cardiac end of the stomach is infiltrated. The best results up to now obtained are said to be: by jejunostomy a prolongation of life for a few weeks; by gastro-enterostomy a prolongation on an average of three to five months; by partial or complete gastrectomy a prolongation of life for two years, over and above the year the untreated disease may be expected to last. But of these there are some cases in which there has been no recurrence for four years or more; a few patients have lived so long that they may be said to have been cured altogether. Supposing a more rapid diagnosis and an earlier resort to exploration, 50 per cent. of all cases of cancer of the stomach might obtain this average prolongation of life of two years. The

FIG. 418.—Method of performing pyloroplasty, diagrammatically shown. (From Esmarch and Kowalzig.)

experience of one of us (Walsham) in gastro-enterostomy for cancer of the pylorus would lead him to place the average prolongation of life much higher than that above given.

Operations for simple pyloric stenosis.—*Rapid dilatation of the pyloric end of the stomach for simple fibrous stricture* (*Loreta's operation*) consists in opening the stomach and then dilating the pyloric end with the finger or dilators. The wound in the stomach is then closed by Lembert's suture, and the abdominal parietes united. The operation has been sometimes followed by death from hæmorrhage or peritonitis, and there is a tendency for the stricture to recur. Pyloroplasty is now generally substituted for dilatation of the pylorus. Stenosis of the *cardiac* orifice has been treated in the same way.

Pyloroplasty.—After having opened the abdomen in the middle line above the umbilicus, the pylorus is drawn forwards into the wound and the peritoneum protected by packing round with gauze or sponges. A longitudinal incision is next made from the stomach to the duodenum on a probe or director previously passed through

the stricture. The centre of the wound on each side is retracted until it is diamond shaped (Fig. 418), and the wound is then closed by a double row of sutures in the vertical direction; the deeper should involve all the coats, the superficial one only the serous and muscular coats. This operation may be usefully employed for non-malignant stricture, but cases in which there is marked hypertrophy or a suspicion of malignant disease, and those in which the pylorus is embedded in adhesions, are unsuitable, and are better treated by gastro-enterostomy or by pylorectomy. After the operation the patient is given nutrient enemata until water is kept down, and then careful feeding is proceeded with.

Gastroplication or gastrorrhaphy is especially indicated when the amount of dilatation tends to cause a kink at the pylorus. Since the stomach-wall in such cases has undergone much atrophy the object in view is to shape the stomach so as to allow food to pass as quickly as possible into the intestines where it can be digested and absorbed. Gastroplication is therefore generally an adjunct to pyloroplasty. By interrupted sutures tucks are made along the front wall of the stomach, so as to make the stomach into a tube leading from the œsophagus downwards to the duodenum. The alternative operation is gastro-enterostomy.

Operations for carcinoma of the stomach.—Pylorectomy and partial gastrectomy.—*Pylorectomy*, the excision of the pylorus only, is generally speaking insufficient for the removal of malignant growths. Only when the surgeon is afraid that by doing gastro-enterostomy he may be leaving a pylorus which will gradually prove itself malignant would such an operation be indicated. Therefore, a mere excision of the pylorus will be doing too little or too much. *Partial gastrectomy* is an extension of pylorectomy, so that the pyloric third of the stomach as well as the pylorus and such of the glands as are affected are removed. The tumour is first exposed and its malignant nature confirmed by its nodular characters, surrounding induration, and commencing enlargement of the glands. Before commencing its excision, the fingers must be passed behind the pylorus, one through the gastro-hepatic omentum, the other through the gastro-colic omentum. If the tumour is extensively fixed to the pancreas and if enlarged glands can be felt in the neighbourhood of the cæliac axis, excision is contra-indicated, but adhesions to the abdominal wall, liver, gall-bladder, or colon may be successfully dealt with by careful division and dissection.

The operation is commenced by dissecting up the enlarged glands along the lesser curvature from the left coronary artery towards the pylorus, and then in like manner dealing with the glands along the greater curvature. The tumour is next raised from its posterior attachments together with the enlarged glands. The pylorus is isolated by ligatures from the gastro-hepatic omentum above, and from the gastro-colic omentum below, drawn forwards, the peritoneum

protected, clamps are applied on the healthy stomach and duodenum, and the tumour cut away with an inch of healthy tissue beyond, bleeding points being clamped and tied. In order to make the duodenal opening as large as that of the stomach, a longitudinal incision is made in the duodenum opposite to its blood-vessels. The cut ends of the duodenum and stomach are then sutured together, first by a deep row of sutures through all the coats, and then by a superficial row through the serous and muscular coats only (Fig. 211, p. 535). As this fitting together by sutures takes a considerable time, some think it better to completely close the stump of the stomach and duodenum separately by a continuous Lembert suture, and then to perform a gastro-enterostomy by suture (Fig. 228, p. 544), or with Murphy's button (Fig. 225, p. 542).

Total gastrectomy, which has now been done many times, is performed in a similar manner to the above, but in order to reach the cardiac orifice underneath the ribs, a larger abdominal incision is required, whilst a bolster placed behind the patient's lower ribs will further facilitate the steps of the operation by making the stomach more prominent. After removal of the stomach the duodenum may be joined end to end with the œsophagus, or if it will not reach, may be inverted and closed, and a loop of jejunum brought up and joined on to the œsophagus.

After-treatment for all operations on the stomach.—The patient's head and shoulders should be a little raised. He should be fed with nutrient enemata containing ʒss. to ʒj. of brandy every three hours. Morphine and atropine are injected to prevent vomiting, and this may be repeated at regular intervals every two or three hours. As soon as the patient can keep down water, sips of champagne and liquid food must be given by the mouth. Liquid food is required during convalescence at frequent intervals, the more frequent the larger the extent of stomach removed. When the whole stomach has been excised and the patient recovered, liquid or semi-solid easily-digestible food has been required every two hours.

Gastro-enterostomy consists in forming a fistulous opening between the stomach and small intestine to allow the contents of the stomach to pass out when the pylorus is obstructed. Three methods are at present in use :—

(1) *Gastro-duodenostomy.*—A communication is made between the stomach and descending portion of the duodenum. Its merit is that the gastric contents enter the intestine above the bile-papilla and hence there is less danger of regurgitation of bile. But it cannot be carried out when the pyloric third of the stomach or the duodenum is involved by adhesions or new growth.

(2) *Anterior præcolic gastro-jejunostomy* (Fig. 420, A and B).—This is a relatively easy operation, which allows of a good length of gut being fixed to the stomach, so that a spur is avoided and the regurgitation of bile prevented. The objection against it is that a

loop of small intestine has to be brought up in front of the transverse colon (Fig. 420, B), which it may obstruct. To prevent this a coil of gut must be selected about two feet from the duodeno-jejunal junction, and at least three inches be fixed in a line to the anterior wall of the stomach. To find this coil raise the transverse colon near the splenic flexure, pass the hand along the under surface of the mesocolon to the left of the spine, and pick up the coil of small intestines which lies there.

(3) *Posterior retro-colic gastro-jejunostomy* (Fig. 420, A and C).—A loop of jejunum is attached to the posterior surface of the stomach through a hole made in the mesocolon. The omentum and mesocolon are raised, a longitudinal incision made in the mesocolon, and the stomach drawn through. Alternatively the gastro-colic omentum and then the mesocolon are perforated and a loop of

FIG. 419.—Part of the stomach and jejunum from a case of gastro-enterostomy for malignant growth at the pylorus. A. Stomach. B. Jejunum. The bone plates are still *in situ*. The plate in the jejunum is seen. (St. Bartholomew's Hospital Museum.)

bowel drawn upwards and fixed to the posterior wall of the stomach. The advantage of this operation is the communication with the posterior wall of the stomach behind the colon; its danger, the sharp bend of the loop tending to the formation of a spur, and the regurgitation of bile into the stomach and hence bilious vomiting. It cannot be employed when this part of the stomach is involved by the cancer.

Gastro-enterostomy is indicated (1) for inoperable cancer, as by its means life may be prolonged many months, the mortality following the operation having fallen to about 20 per cent. One or two well-authenticated cases have lived over three years before dying of cancer. (2) For pyloric stenosis with dilatation and for persistent ulceration with recurrent hæmorrhages, when pyloroplasty is unsuitable. (3) For congenital hypertrophic pyloric stenosis it has been successfully performed on an infant aged four weeks. (4) After excision of the pylorus to save the time required to sew the stomach

appendix, and it may be only on opening the abdomen that the perforation can be located. If, therefore, the stomach is found intact the search should be extended to the other viscera named.

Treatment.—The abdomen should be opened in the middle line above the umbilicus; the perforation, which is usually quite small, clean cut, and situated upon the anterior surface of the stomach, sought, tucked inwards (Fig. 414), and the peritoneal coats brought into contact over the perforation by a double row of Lembert's sutures (Fig. 207). If little soiling of the peritoneum has taken place, the area of extravasation only should be sponged clean and the wound closed; but if extensive extravasation has occurred, the peritoneal cavity should be well flushed out, and a gauze drain placed in the wound and in counter-openings in the loins and above

FIG. 414.—A stomach opened to show the puckering of the mucous membrane after suture for perforating ulcer. (St. Bartholomew's Hospital Museum, No. 1918 a^1.)

the pubes. Some advise that a portion of the stomach wall around the hole should be excised, and a continuous suture placed in the mucous membrane, and a second row of Lembert's sutures in the peritoneal and muscular coats. This, however, is generally not necessary nor advisable. In many cases it is doubtful if suture of the mucous membrane be possible. When the perforation is surrounded by induration, especially when it is near the pyloric or cardiac orifice, it is difficult or impossible to invaginate, and dangerous to excise. In such cases the hole may be filled by a piece of omentum, which becomes firmly united and forms a plug. When far up under the ribs near the cardiac orifice a long strip of iodoform gauze should be packed in the peritoneum to form a drainage tract from the ulcer to the external wound, and withdrawn a little at each daily dressing.

2. *Subphrenic or perigastric abscess.*—An ulcer on the posterior wall may slowly leak into the lesser peritoneal cavity, and if the

and the proximal end into the duodenum lower down. All these proceedings consume much time, and should certainly not be undertaken when the patient's only chance depends upon the rapidity with which the operation can be performed.

Jejunostomy is the operation of forming an artificial opening for the introduction of food directly into the jejunum when the stomach has become extensively involved by cancer, so that both gastrectomy and gastro-jejunostomy are impracticable. The operation should be done on the lines of gastrostomy (p. 825). Performed thus, patients have been rendered comfortable, and their lives prolonged for some weeks.

Hæmatemesis after operation.—Profuse hæmatemesis ending fatally may follow an abdominal operation unconnected with the stomach, without any lesion of the stomach being discovered at the post-mortem examination. The hæmorrhage is a capillary oozing through the intact mucosa and appears to follow a vaso-motor paralysis of the splanchnic vessels. It has occurred most frequently after operations on the gall-bladder, also after operations for strangulated hernia, removal of omentum and ovariotomy, after exploratory laparotomy and tuberculous peritonitis. But apart from operation it may appear as a late symptom (black vomit) in intestinal obstruction and appendicitis, and during convalescence from typhoid fever. These cases do not seem to be connected with sepsis. Duodenal ulceration and perforation into a gastro-duodenal artery may follow septic operations, just as it has been noted occasionally after burns. Thus patients have died from hæmatemesis from this cause during convalescence from operations for cancer of the pharynx, of the rectum, etc.

The *treatment* consists in absolute rest, rectal feeding, and morphine and atropine injections at frequent intervals to stop the vomiting.

Duodenal ulceration occurs most commonly in men about forty as compared with gastric ulceration which is more frequent in young women. In some cases no symptoms have preceded perforation, which gives rise to acute pain below the right costal arch, often extending downwards to the right iliac fossa, collapse, subnormal temperature, feeble pulse, with increasing rigidity of the abdominal muscles and loss of liver dulness. Vomiting is often absent, or may be slight and merely gastric. Such a case cannot be distinguished from gastric ulceration, nor need it be; the treatment is similar, and in the vast majority of cases the ulcer has been found not more than two inches from the pylorus. A subacute perforation may give rise to a perigastric or subphrenic abscess. Some cases run a slow course, and are indicated by recurring attacks of melæna, or by vomiting of blood mixed with bile. When more chronic still, a stenosis of the duodenum is set up with wasting, dilatation of the stomach, without bile in the vomit. Suture of the perforation and

appendix, and it may be only on opening the abdomen that the perforation can be located. If, therefore, the stomach is found intact the search should be extended to the other viscera named.

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2. *Subphrenic or perigastric abscess.*—An ulcer on the posterior wall may slowly leak into the lesser peritoneal cavity, and if the

(1) *Rupture into the peritoneal cavity.*—Bile, when sterile, may escape in large quantities into the peritoneum without at once setting up peritonitis, but if already infected with pyogenic cocci, rapidly fatal peritonitis will ensue. At times, however, the extravasation may be limited by adhesions and a *perinephritic* or *subphrenic abscess* may form, and into either of these gall-stones may escape. Hence the occasional presence of a biliary calculus on opening an abscess in the loin and the somewhat rare phenomenon of the expectoration of a gall-stone should such a subphrenic abscess penetrate the diaphragm and involve the pleura and lung. (2) *Rupture into the intestine.*—It is the duodenum, and less often the colon, that is most frequently involved. Through the fistula thus formed a large calculus may escape and give rise to intestinal obstruction. (3) *Rupture into the pelvis of the kidney* is rare. Bile and gall-stones may then pass directly into the urine. (4) *Rupture on the skin surface.*—Here an external biliary fistula may be formed by the adhesion of the gall-bladder to the abdominal wall and the formation of an abscess from which, after it has burst on the surface, gall-stones may be discharged. The umbilicus is the commonest place of the rupture, extension taking place along the course of the obliterated umbilical vein.

Empyema of the gall-bladder.—Gall-stones may remain latent in the gall-bladder, merely causing intermittent attacks of pain and jaundice. Inflammation and suppuration, however, may at times occur, possibly as the result of invasion through the duct by the bacillus coli communis; occasionally as a secondary pyæmic process. The suppuration is attended by general fever, and the abdominal walls covering the distended gall-bladder become rigid and inflamed. In the course of typhoid fever the gall-bladder is often distended owing to cholecystitis which may subside, or go on to suppuration, ulceration of the wall and perforation into the abdominal cavity.

Obstruction of the gall-ducts by calculi.—The cystic, hepatic, or common duct may become obstructed by inspissated mucus, or by the impaction of a biliary calculus. When the obstruction is confined to the cystic duct there is distension of the gall-bladder, but no jaundice; when confined to the hepatic duct there is jaundice but no distension; when involving the common duct there is jaundice with distension of the ducts above, but not necessarily of the gall-bladder. The obstruction may be merely temporary during the passage of a stone which gives rise to an attack of gall-stone colic. When such attacks are frequently repeated, and no gall-stone is discovered in the fæces, it is probable that the stone is too large to pass, but from time to time descends into the cystic or common duct, where it acts like a ball-valve and then falls back again into the gall-bladder or into a dilatation, allowing bile to pass (*recurring biliary colic*). The pain with vomiting during these attacks exhausts the patient, and is in itself an indication for an exploratory operation, even when

no distension of the gall-bladder can be made out. In such a case the jaundice follows an attack of pain after twenty-four to thirty-six hours. When a calculus lodges in the diverticulum of Vater there is an intermittent flow of bile, causing the jaundice to vary without disappearing, but attended with intermittent febrile attacks, with some enlargement of the spleen but not of the liver. The patient does not feel ill, nor does he lose weight.

Compression of the common duct.—The common duct may be involved in adhesions about the pylorus, or be compressed by a tumour, or by the inflammatory swelling in chronic pancreatitis, or be kinked by displacement of the liver.

Malignant disease of the gall-bladder and ducts.—In a large number of cases this is undoubtedly due to the prolonged irritation of a stone. In the case of the gall-bladder there is usually a history pointing to chronic cholecystitis; on this follows the growth of an irregular nodular tumour continuous with the liver, which is invaded directly from the gall-bladder. Malignant disease involving the hepatic or common duct may begin quite insidiously in a painless manner with slowly increasing jaundice until there is complete obstruction. When there is also rapid loss of weight and distension of the gall-bladder, cancer of the head of the pancreas is indicated. If with the jaundice the loss of weight is not so rapid, the cancer may be around a calculus in the lower part of the common duct, but pancreatic fluid still escapes and fat is absorbed. Increasing jaundice with steady enlargement of the liver, painless and without fever, points to malignant disease involving the hepatic ducts, and this is generally secondary to a like growth in the pancreas or elsewhere.

OPERATIONS ON THE GALL-BLADDER.

Cholecystotomy is the incision of the gall-bladder, **Cholecystostomy** the combination of incision and drainage, **Cholelithotomy** incision and removal of calculi. Aspiration through the abdominal wall is not only dangerous but useless. These operations are required for a chronically distended gall-bladder, and for an acute empyema, and for persistent pain and tenderness over the position of the gall-bladder. A sand-bag is placed under the patient's lower ribs which throws forwards the gall-bladder and ducts, whilst the intestines slip downwards. Make a vertical incision in the linea semilunaris, beginning just below the ninth right costal cartilage, or over the tumour when the gall-bladder is distended (Fig. 407, F). Having divided the abdominal parietes and stopped all bleeding, open the peritoneum. Search for the gall-bladder with the finger beneath the liver if it does not present in the wound, and bring it to the surface if practicable. Pack the wound with sponges to prevent any fluid escaping into the peritoneal cavity, and introduce an aspirator-needle into the gall-bladder, which, as the fluid escapes, should be

well drawn into the wound. Enlarge the opening in the gall-bladder and remove any gall-stones found loose. If a stone is found impacted in the cystic duct, extract it, if possible, by forceps, by gentle manipulation with the fingers in the abdomen, by careful crushing with padded forceps, by breaking it with a needle passed through the wall of the duct, or by chipping off fragments as it lies in the duct. Secure the edges of the aperture in the gall-bladder to the abdominal wall by sutures, with its peritoneal coat well in contact with the

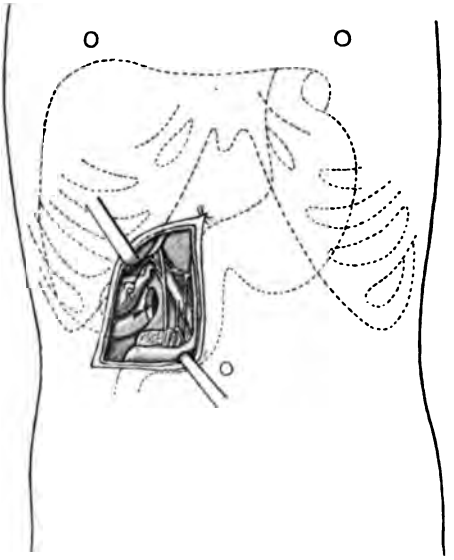


FIG. 421.—Diagram showing the anatomical relations of the gall bladder and ducts as exposed by an oblique incision parallel to the lower margin of the ribs from the middle line outwards. The gall-bladder with its cystic duct is seen joining with the hepatic duct to form the common duct which passes down in front of the foramen of Winslow (indicated by the arrow) through the head of the pancreas to the duodenum. Behind the common duct is the large portal vein with the hepatic artery, both of which in their passage to the liver give off branches to the pancreas and gall-bladder.

parietal peritoneum; leave a drain tube in the gall-bladder; and close the rest of the abdominal wound in the way already described. The biliary fistula thus left may close in a few weeks if the cystic duct has been cleared.

Cholecystendysis is the operation of opening the gall-bladder by a small incision, removing the stone, and then closing the wound by a continuous silk suture through the mucous and muscular coats, and by a second or even third row of Lembert's sutures through the muscular and peritoneal coats. After the proper toilet of the peritoneum has been made, the wound in the parietes is then closed

or an aseptic gauze drain inserted. It should only be done when the walls of the gall-bladder and the bile are quite healthy; or for small penetrating wounds or a small rupture of the gall-bladder in the neighbourhood of the fundus. This operation is contra-indicated when there is obstruction in the common bile-duct, when the walls are inflamed and the gall-bladder contains a purulent fluid.

Cholecystectomy, or the excision of the gall-bladder, has come to be the operation now most generally performed. It prevents recurrent cholecystitis, re-formation of gall-stones, the persistency of a biliary fistula, and the possibility of cancer being ultimately set up in a diseased structure. The patient does not apparently suffer from the loss of the gall-bladder. It is especially required: 1, where perforation following suppuration and ulceration has occurred, and the coats are found too softened to admit of suture; 2, where cholecystotomy is indicated, but on opening the abdomen the gall-bladder is found so contracted that its fundus cannot be drawn into contact with the abdominal walls without tearing it; 3, for the cure of a persistent biliary fistula when the common duct is patent; and 4, for early cancer. It is especially contra-indicated in empyema with septic inflammation around. The gall-bladder is then drained, and may be excised later if thought desirable. Make an incision similar to that for cholecystotomy, prolonging it or dividing the muscles transversely a little below the ribs if more room is required. Having well packed the wound with sponges to prevent blood escaping into the general peritoneal cavity, dissect the gall-bladder from the liver, clamping or tying any bleeding vessels, ligature the cystic duct, cut away the gall-bladder, touch the stump with carbolic acid, remove the sponges, and unite the abdominal walls in the usual way.

Cholecystenterostomy, or the establishment of an opening between the gall-bladder and the intestine, may occasionally be required for irremoveable obstruction of the common bile-duct, as from simple stricture due to calculi, or cancer about the head of the pancreas, duodenum, etc., involving the duct. Having opened the abdomen as in other operations on the gall-bladder, draw the gall-bladder and duodenum into the wound, and having made an incision into each, unite them by a double row of sutures (p. 544), or by a small Murphy's button. When the latter method is employed a running thread is first passed, as shown in Fig. 230, through all the coats of the duodenum, and then another thread in like manner through all the coats of the gall-bladder. An incision is next made into the duodenum within the running thread (see Fig. 230) two-thirds of the length of the diameter of the button to be used, the button slipped in, and the thread tightly tied round the central cylinder (see p. 543). A similar incision is made in the gall-bladder, its contents evacuated, the other half of the button inserted and secured by the running thread in a similar way. The two halves of the button, held by the fingers in the way shown in Fig. 422,

are now pressed together, thus fixing the serous surfaces in contact. The spring in the button produces pressure-atrophy of the tissues embraced by it, leaving an opening as large as the button, which, thus freed, is passed *per anum*.

Choledochotomy or Choledocho-lithotomy are the terms applied to removal of a gall-stone impacted in the common bile-duct. Having opened the abdomen the finger follows the gall-bladder, cystic duct, and common bile-duct as it lies in the gastro-hepatic omentum and behind the first portion of the duodenum. Passing the finger into the foramen of Winslow will often aid in detecting the calculus. The duct with the gastro-hepatic omentum

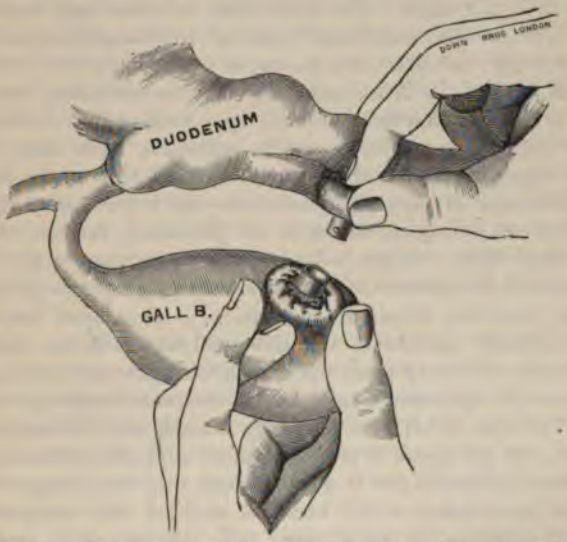


FIG. 422.—Male and female half of Murphy's button, fixed *in situ* and ready for pressing together. (After Murphy.)

is drawn into the wound, an incision, parallel to the long axis of the duct, made over the calculus, and the latter removed after first breaking it up, if large, with forceps. The mucous membrane of the duct is united by a fine silk suture, and then the muscular and serous coats. If the sutures cannot be inserted it is no great matter, as the wound closes spontaneously in a few days. The wound in the parietes is then closed, or a gauze drain inserted. A small instrument resembling in shape a hammer or croquet mallet may be inserted into the wound in the duct, so as to hook the duct forward whilst the sutures are being inserted. If near the end of the duct the stone may be reached by cutting into the duodenum, which must be afterwards carefully sutured. Care must be taken not to injure the portal vein from which hæmorrhage has

proved fatal, though it has been controlled by lateral ligature. If the duct has been effectually sutured the abdominal wound may then be closed, or better only partially closed, a gauze drain being passed down to the duct when the duct is not sutured.

Choledochectomy, or excision of a portion of the common bile-duct for localised malignant growths, etc., has been performed a few times. It must be combined with cholecystenterostomy.

SURGERY OF THE LIVER.

Hydatid cysts of the liver (see p. 163) are usually unilocular and filled with daughter cysts varying in size from pin's-heads to grapes or hen's eggs. The fluid may be abundant or the whole mass have become inspissated and of the consistency of cheese. Less often acephalocysts are met with. The cysts may be single or multiple, and in the latter case they may communicate secondarily. There is a well-marked parasitic cyst-wall, which before inflammatory complications have set in separates with ease from the fibrous capsule or adventitious cyst. The latter where formed by liver substance is very thin and has very large veins, which it is important not to injure, whilst in the projecting portion of the cyst it is fairly thick. *Signs.*—An hydatid cyst causes a slow painless enlargement of a portion of the liver without other special symptoms such as jaundice, fever, or emaciation. The cyst may project from the under surface of the liver and be felt in the right hypochondrium, or it may push up the diaphragm and encroach upon the thorax, at the same time pressing down the liver-edge below the ribs. The cyst is felt as a perfectly smooth and exceedingly tense tumour. If left alone it may suppurate and the patient die from fever and exhaustion; or it may rupture into the thorax and lung; into the peritoneum, which becomes studded with daughter cysts; into the intestine, or vena cava; into the gall-ducts, and set up symptoms of biliary colic; into the pelvis of the right kidney and set up renal colic. Generally a rupture is fatal; exceptionally recovery follows the coughing up of hydatid shreds or their escape into the bowel or urinary tract or externally at the umbilicus. *Treatment.*—Aspiration, having for its object the drawing off of fluid and the consequent death of the parasite and shrinkage of the cyst, should be entirely given up since it has been immediately fatal in more than 20 per cent. of the cases, and fails to cure in more than half. Thus, fatal results have followed the escape of fluid under high tension into the peritoneum or surrounding tissue; or acute local œdema is set up, also a form of general urticaria; or a vessel may be punctured which bleeds into the cyst cavity as fast as the fluid is withdrawn. Moreover, even after aspiration and desiccation the cyst may undergo chronic inflammation and suppuration. Of course, aspiration is of no service when the contents have become

consolidated. An hydatid cyst should always be treated by incision and removal of the parasitic cyst as early as possible before inflammatory complications have set in. When suppuration has begun the treatment is the same as that for abscess. According to its position the cyst is removed through an anterior or posterior incision.

Anterior incision.—The abdomen is opened by a short incision in the right linea semilunaris, which can be enlarged downwards or horizontally outwards if desired. The projecting cyst is surrounded by sponges, or a portion of the liver is selected which feels very tense. A trocar and cannula is plunged in and the fluid allowed to escape; then the puncture is gently dilated by forceps and by the finger until the white parasitic cyst can be seized with cyst-forceps. The nozzle of an irrigator is next passed between the parasitic and adventitious cyst, and a very gentle stream of water will detach and float up the former, so that it can be delivered through the small opening. If great gentleness is used none of the parasitic cyst is left behind. When the cyst is full of daughter cysts, the opening is made large enough for them to escape. If the contents are semi-solid, a blunt spoon is employed to scoop them out. Having well irrigated the cavity left by the parasitic cyst, taking the greatest care not to injure the wall and start hæmorrhage, the opening is closed by sutures and the abdominal wound closed in the usual way.

Posterior incision.—When the cyst can only be reached from behind, a length of the tenth, eleventh, or twelfth rib must be removed, the pleural cavity opened, the diaphragm stitched to the upper edge of the incision so as to shut off the pleura, and the diaphragm cut through and the liver exposed. The lung collapses very little, and quickly expands again when the pleural cavity is shut off as described.

Abscess of the liver.—The abscesses of the liver that can be treated successfully are (*a*) the *single tropical abscess* commonly following on dysentery and in patients exhausted by malaria, and (*b*) the abscess due to a suppurating hydatid cyst. Multiple pyæmic abscesses, from whatever source, are beyond surgical measures. Abscesses due to gall-stones will be referred to under the surgery of the gall-bladder.

A tropical abscess contains amœbæ in its wall, if not in the pus, but, when uncomplicated, no pyogenic organisms. This is an important point, but advanced cases and suppurating hydatid cysts are generally infected. The *symptoms* of an abscess are sharp, local pain from inflammation of the serous surface, which becomes throbbing as suppuration sets in, with rigidity of the right rectus, a continual fever with intermittent rigors, sweats, progressive debility, and but slight or no jaundice. The liver enlarges and the abscess may come to the surface and point below the ribs. It may

cause an empyema or burst into the lung. When the above unfavourable symptoms persist, an exploration should be made; if there is a delay until fluctuation is obtained the patient may become too weak. Aspiration without incision should not be done. If the pus is near the surface it is needless; if deep, vessels may be injured. Further, the result may be negative because the pus is too thick to pass through the needle easily, and as the needle is withdrawn pus may be extravasated and infect the peritoneum. An incision should always be made; if the peritoneum is not adherent, the cavity is protected by sponges. A trocar is passed into the abscess cavity and along the trocar the blade of a Paquelin's cautery at dull red heat. Into the cavity a large drainage tube is pushed which has no side holes. Through the tube the cavity is washed out with hot water until pus and sloughs are got away; then the tube is packed round with gauze before withdrawing the sponges protecting the peritoneum. If favourable, the pus and sloughs are chocolate coloured and non-odorous, and pyogenic germs are absent. If dark-coloured material like prune juice, or bright red material like raspberry jam, continues to escape, an extensive destruction of liver-substance is in progress and the outlook is bad. When the abscess cavity is near the surface and thick-walled, especially when caused by a suppurating hydatid, a larger opening should be made, all the sloughs, parasitic membrane, etc., carefully sponged out, and the interior filled with iodoform gauze strips, which are frequently changed. An abscess may have to be reached across the pleura. Hæmorrhage is easily controlled by pressure, or packing with gauze. Measures not now advisable are: (1) aspiration, or exploratory puncture owing to the danger of hæmorrhage. (2) Dr. Manson's method of inserting a large trocar and cannula, withdrawing the trocar, passing a rubber catheter through the cannula, and drawing back the cannula over it. The objections to this course are (*a*) hæmorrhage, (*b*) leakage into the pleural or peritoneal cavity, (*c*) incomplete evacuation of pus so that septic absorption continues. (3) Operating on two occasions, on the first exposing the peritoneum and waiting for adhesions, before incising the abscess. This is now unnecessary owing to the use of gauze packing, for the patient is unrelieved by the first operation and complications may supervene before the second can be performed.

Tumours of the liver.—A single tumour projecting from the liver below the ribs, not connected with the gall-bladder, not of metastatic origin, and not yielding to iodide of potassium, should be explored through an incision. A pedunculated *adenoma* may be removed by the intra-peritoneal method of ligature, or more safely by suturing the parietal peritoneum round the neck of the pedicle, cutting across with the cautery, ligaturing the vessels, and dressing the stump with iodoform gauze. In this way recurrent hæmorrhage into the peritoneum is avoided. A shrunken *hydatid*

cyst has been excised, the cavity left being dressed with gauze. The tumour should be outlined from the surrounding liver-substance by the cautery knife at dull red heat. The section of such a tumour has a peculiar foliate appearance owing to the folded parasitic cyst walls, and hooklets are found (see p. 162, Fig. 60, 10). *Gummata* not relieved by iodide of potassium have been excised when pedunculated, or fixed to the abdominal wall, the interior scooped out, and a strip of gauze inserted. Care should be taken not to interfere by puncture or otherwise with a *malignant* tumour of the liver, for simple puncture has been followed by continuous and fatal hæmorrhage. Except when malignant disease has extended from the gall-bladder to the liver, these tumours are generally secondary.

Disease of the portal vein.—The *portal vein* anastomoses with branches of the inferior vena cava, especially there is an anastomosis between the upper and lower hæmorrhoidal veins, which is important in the case of hæmorrhoids, and to a less extent between mesenteric and intestinal branches of the portal vein and those of the abdominal wall. The portal vein anastomoses with the umbilical vein in the suspensory ligament, with the left coronary and the œsophageal vein, which occasionally become over-distended and bleed in cases of portal obstruction from cirrhosis.

Pylethrombosis, or simple obstruction of the portal vein, occurs especially in cirrhosis of the liver, also in syphilis and from tumours and peritoneal inflammations, due to bacteria not virulent enough to cause suppuration. Obstruction of the portal vein itself is especially indicated by ascites, of the splenic vein by hæmatemesis, and of the superior mesenteric by pain, vomiting, and collapse.

Septic pylephlebitis is generally derived from the gastro-intestinal tract, and is rarely retrograde in origin from the liver. It is especially caused by suppuration in the neighbourhood of the cæcum and appendix, whereas it does not occur in extensive cases of ulceration such as follow dysentery and typhoid fever. It gives rise to severe rigors and profuse sweating, with marked enlargement of the liver and jaundice.

Multiple abscesses form in the liver in the course of pyæmia. If the pus bursts into the bile-ducts the only proposal for treatment is drainage of the gall-bladder.

Paracentesis abdominis, or *tapping the abdomen for ascites*, should be done in the linea alba midway between the umbilicus and the pubes (Fig. 407, A). The bladder having been emptied, a small incision should be made through the skin, and the trocar and cannula, with a tube attached to convey the fluid into a vessel, should be thrust into the abdomen. If the patient is fat, the abdominal wall will be as much as three inches or more in thickness. The fluid should be drawn off slowly, and a many-tailed bandage, previously passed round the body, gradually tightened as the fluid

flows in order to keep up pressure on the abdominal vessels, and so prevent syncope. The fluid may be drawn off with a Southey's trocar and cannula. When this is used a skin incision is not necessary, nor is the many-tailed bandage, since the abdomen takes many hours to empty on account of the small size of the cannula, and there is thus no fear of syncope. But a constant leakage beside the cannula may cause eczema and even erysipelas. When paracentesis is repeated the omentum adhering to the abdominal parietes may be wounded, and there is then fresh blood mixed with the serous fluid.

Drainage of the abdomen.—A short incision is made and an exploration with the finger completes or corrects the diagnosis. The abdominal cavity is then washed out and a glass tube passed down into the pelvis, which is joined to a rubber tube to lead off the fluid into a vessel under the bed. The fluid then drains away until the tube is blocked with fibrin, and adhesions form within four to six days.

Artificial venous anastomosis between the portal and general circulation. Cases of ascites are often tapped a great number of times; one patient had 250 gallons of fluid removed in 150 tappings. After repeated tappings patients have spontaneously improved, whilst the fluid has ceased to re-collect. Coincident with this improvement the superficial veins of the front of the abdomen and chest have become enlarged, the condition from its appearance being fancifully named "caput medusæ." The blood in such enlarged veins can be seen to flow upwards. To artificially produce this anastomosis, Drs. Talma and Morrison introduced the operation of fixing the omentum between the deeper layers of the abdominal wall. This must be done through an epigastric incision about two inches in length, in order to avoid the danger of an omental band beneath which a loop of intestine may slip and become strangulated. The inner surface of the parietes, and the anterior and upper surface of the liver, may be scrubbed with a sponge to favour the formation of adhesions. A little piece of omentum is drawn up, yet not so much as to be strangulated by the wound, and is sutured to the parietal peritoneum and recti muscles and the skin united over it. This procedure may be combined with hypogastric drainage, and in about a month the patient will be able to get up, wearing a belt. The superficial veins gradually enlarge and the patient is relieved from the frequent accumulation of fluid. The prognosis varies with the cause of the ascites; some cases have been permanently relieved. But the operation should not be employed as a last resource, as confidence in it will be weakened by the high mortality which is then attributed to it. Post-mortem examinations show that a very free anastomosis between the portal and parietal vessels is established, large vessels being found in the adhesions. Obviously the operation tends to relieve the over-distended veins of the portal system, and to influence ascites when resulting mainly from obstruction to the

venous circulation through the liver. But this is only one of the known or unknown factors connected with the peritoneal exudations.

Ptosis of the liver and other viscera.—Glénard's disease.—The liver is displaced downwards in the abdomen; combined with this is an elongation of the right lobe down towards the iliac fossa, forming the floating, appendicular or linguiform lobe of Reidal. Glénard described the liver as being held in position mainly by the vena cava and by intra-abdominal tension, so that the heavier right lobe sinks forward, whereby the anterior edge points downwards and the convex surface forwards. The anterior edge is in addition thinned out and prolonged from the lobe, being very often partly constricted by a fibrous band formed from a thickening of the visceral peritoneum. Glénard's disease is nearly always seen in women, owing to general abdominal relaxation, such as occurs after repeated pregnancies. Glénard found evidence of liver and biliary disease in many of these cases, especially in the few male patients. The disease has been attributed to tight lacing, but this is probably not the cause, since the transverse bands on the liver supposed to indicate such pressure appear to be of congenital origin. In examining a patient the loin is grasped with the left hand, whilst the right hand pushes up the intestines, and then the elongated lobe is to be felt with the left thumb. The symptoms are dragging sensations, indigestion, attacks of colic and jaundice from kinking of the bile-duct. The diagnosis must be made from floating kidney and gall-bladder distension.

Treatment.—Generally a proper well-fitting belt is sufficient along with regulation of the bowels, diet and exercises, and in extreme cases fixation of the liver to the anterior parietes through an incision in the right linea semilunaris. Any gall-stones are removed at the same time, but not the prolonged linguiform lobe.

SURGERY OF THE PANCREAS, SPLEEN, AND MESENTERY.

Hæmorrhagic and gangrenous pancreatitis; fat necrosis; pancreatic abscess.—When bile was experimentally injected into the pancreatic duct of a dog by Dr. Opie, the result was a series of hæmorrhages into the substance and around the pancreas, into the omentum, mesentery, and retro-peritoneal fat, as a consequence of fat necrosis. The further interest of the experiment lies in the fact that this hæmorrhagic condition can be produced by bile apart from the presence of organisms. It is supposed that the isolated patches of fat necrosis are the result of diffusion of the pancreatic secretion and its ferment. Hæmorrhagic pancreatitis is seen in man especially when a calculus obstructs the duodenal papilla so that the bile regurgitates along the pancreatic duct. This may occur without septic infection (*aseptic hæmorrhagic pancreatitis*). The onset of the disease may be sudden, the symptoms being localised pain and

collapse. On operating the pancreas has been found a blackish-red mass with islands of similar appearance in the fat around, though micro-organisms may be absent. The result of operations has been so uniformly unsuccessful, only two cases recovering out of twenty-five or more, that this condition being found, the operation should be stopped and a gauze plug inserted in the hope that resolution will follow. The case, if treated expectantly, may terminate in the formation of a cyst or in sclerosis.

Septic hæmorrhagic pancreatitis may occur from secondary infection of the preceding form by staphylococci, or by the colon bacillus or may follow an injury such as a bullet wound, biliary, gastric or intestinal ulceration, etc. The result may be a gangrene with diffuse suppuration involving the pancreas and the surrounding tissues. It is indicated by signs of septic inflammation in addition to collapse, and it is then hopeless to operate. Or the suppuration may be circumscribed and an abscess form. Such an abscess has burst into the bowel and the patient spontaneously recovered. A circumscribed abscess forms rapidly with signs of acute septic inflammation in the region of the pancreas. It should be incised, the interior cleared of pus and sloughs with all gentleness and filled with gauze or drained. A fistula may remain discharging pancreatic fluid.

Pancreatic cysts.—The simplest cysts occur as obstruction cysts, produced by biliary calculi obstructing the duct, or by calculi in the pancreatic duct itself. In other cases the cyst is the result of a previous hæmorrhagic pancreatitis of the aseptic variety. A tumour is found in the epigastrium attended with more or less pain and signs of pancreatic disease, *i.e.*, fat in the fæces and sugar in the urine, with sometimes bronzing of the skin. On opening the abdomen the cyst is found to be retro-peritoneal attached to the region of the pancreas, and its fluid may be shown to contain pancreatic ferments. The cyst has been drained from the front and by a counter-opening made behind on the left side. It has also been dissected out, remains of pancreatic tissue being found in the wall of the cyst. When following hæmorrhagic pancreatitis altered blood is contained in the cyst cavity.

Treatment.—The cyst should be excised when practicable, otherwise it should be drained.

Chronic interstitial pancreatitis may be the result of cholelithiasis or biliary obstruction, or of the simple form of hæmorrhagic pancreatitis. The resulting sclerosis then causes constriction of the common bile-duct and so gives rise to jaundice and distension of the gall-bladder, accompanied by wasting and paroxysmal attacks of pain and ague-like seizures. If such symptoms arise in patients under forty, chronic interstitial pancreatitis may be suspected, since cancer of the head of the pancreas is rare until after that age. A hard lump may be felt in the region of the head of the pancreas, and if there is also fat in the fæces, sugar in the urine, and bronzing of

the skin, a diagnosis may be arrived at. The treatment is cholecystostomy together with the removal of any gall-stones met with. The result may be a good and lasting recovery.

Tumours of the pancreas.—A *multilocular cystic tumour* of the pancreas has been met with resembling an ovarian cyst; the small cysts are lined with cylindrical or polygonal epithelium and intracystic papillary masses project into them. Such a tumour may be a proliferating cystic adenoma or a cystic carcinoma. If a tumour becomes palpable it should be explored and, if possible, excised.

Sarcomata have been found in the tail of the pancreas, and their removal has been several times attempted, but has been unsuccesful owing to shock or to metastatic growths having already occurred.

Carcinoma of the head of the pancreas is the commonest tumour in this situation. It may be known by the insidious onset and progressive character of the jaundice without pain, fat in the stools, sugar in the urine, and rapid wasting. Later it may cause pain and duodenal and pyloric obstruction with melæna. A fixed nodular tumour in the situation of the pancreas may then be felt together with a distended gall-bladder. *Treatment.*—In some few very early cases attempts have been made to excise the growth, or cholecystenterostomy has been employed, but in cases of true cancer this operation does not appreciably prolong life. There is, however, always the chance that the disease may be simple interstitial inflammation, when opening and draining the gall-bladder proves highly successful.

Abscess of the spleen may be due to a septic infarct or the breaking down of a gumma, or it may follow chronic malarial inflammation and perisplenitis in an exhausted subject. The signs are those of suppuration with distension of the left hypochondrium. An incision should be made into the abscess cavity, also a counter-opening further back if necessary.

A moveable spleen forms an abdominal tumour in the splenic region, in the centre of the abdomen or even in the pelvis, enlarging after meals. It is more common in women. Should the pedicle become twisted the spleen may become immensely engorged and finally gangrenous. If the pedicle can be untwisted the spleen may be fixed in place by suture (*splenoplexy*); if not, the organ must be removed.

Chronic enlargement of the spleen is produced by repeated attacks of malaria; and an enlargement from this cause should be distinguished from that of leucocythemia. It also is met with in splenic anæmia, a profound anæmia of obscure causation in young subjects, which is progressive and ultimately fatal, and associated with great enlargement of the organ without leucocytosis or enlarged glands. The enlargement has proved after excision to have been due to tubercle. Removal is indicated on account of the size of the tumour, recurring attacks of pain and fever, anæmia and emaciation;

but it should not be undertaken when it is accompanied by any considerable leucocythæmia. Patients have recovered health and have remained free from anæmia and fever.

Tumours of the spleen amenable to surgery are primary spleno-megaly, fibro-cystic tumours, slowly growing sarcomata and hydatid cysts.

Splenectomy, or extirpation of the spleen, may be required for rupture of the viscus, and for some forms of enlargement and tumours. It should not be attempted if on exposure extensive adhesions are found, since, unless all these can be securely ligatured, fatal recurrent hæmorrhage is almost certain to occur. An incision is made either in the linea alba, the left linea semilunaris, or still further to the left, and the spleen having been thoroughly exposed, each adhesion carefully tied, and the organ, if enlarged, drawn out of the wound, the pedicle is then transfixed in several places with strong silk, and the ligatures interlocked and tied. The pedicle is next severed well to the splenic side of the ligatures, the organ removed, the peritoneum thoroughly cleansed, and the abdominal wound united without or with drainage. Great care should be taken not to tear the splenic substance, an accident attended with fearful hæmorrhage. An enlarged, adherent, and hence immoveable, spleen has been fixed in the abdominal wound, where it has undergone venous congestion and then atrophy, or gangrene and sloughing followed by complete healing.

INTRAPERITONEAL AND RETROPERITONEAL TUMOURS.

A tumour of the omentum is freely moveable and not covered by intestine. It may consist of rolled up or matted omentum, the result of inflammation, or it may be a cyst or of a vascular, fibrous, or sarcomatous nature. *Treatment.*—An exploratory incision should be made, and if the tumour is found moveable the whole of the omentum should, as a rule, be excised up to the transverse colon.

Mesenteric tumours.—The chief tumours of the mesentery are cysts which may contain serum or blood, when they are probably of traumatic origin, or chyle, when they are due to a dilated and obstructed lacteal vessel. A chyle cyst may also be of congenital origin, a sequestration from the intestine or its neighbourhood, showing an epithelial lining or not, and a wall of muscular or fibrous tissue or both. An hydatid or dermoid cyst and a teratoma or included fœtus may also occur, and sometimes an ovarian cyst may become detached from its pedicle and grafted on to the mesentery. The *special signs* are a moveable tumour covered by resonant intestine. At times there are symptoms of abdominal obstruction. *Treatment.*—The cyst may be either excised, washed out and closed, or be carefully shelled out after pushing aside the mesenteric vessels; only when absolutely necessary should the cyst-wall be sutured to the

abdominal wound and the cyst drained. If the mesenteric vessels are involved the portion of intestine supplied has also to be excised to avoid gangrene.

Retroperitoneal tumours are certain rare tumours which arise behind the peritoneum, having a fixed attachment to the back of the abdomen and the intestines in front. Among these may be included kidney, suprarenal, pelvic, and pancreatic tumours, which are elsewhere described. Of rarer occurrence are the retroperitoneal lipomas, cysts of obscure origin, whether multilocular or dermoid, and lymphadenomatous and lympho-sarcomatous tumours of the lymphatic glands. The diagnosis of such conditions can only be completed by exploration, when it has been found possible in some cases to shell them out.

SURGICAL DISEASES OF THE INTESTINES

INTESTINAL OBSTRUCTION.

The pathological conditions that may give rise to intestinal obstruction are very various, and may be considered under the following heads:—

1, Impaction of fæces, gall-stones or foreign bodies in the intestines; 2, internal strangulation or internal hernia; 3, volvulus; 4, intussusception; 5, stricture of the intestine, consequent upon disease of the intestinal wall; 6, constrictions of the intestine, consequent upon disease beginning external to the intestinal wall; 7, mechanical pressure on the intestines, and kinking of the lumen by innocent or malignant tumours; 8, congenital malformation of the intestines; 9, paralysis of the muscular coat of the intestine; 10, gangrene from embolism and thrombosis of the mesenteric arteries and veins; 11, peritonitis and enteritis; 12, appendicitis and perityphlitis; 13, external hernia; 14, pelvic peritonitis, especially in women. The last three are described under the special headings of *Appendicitis*, p. 881; *Hernia*, p. 893; and *Pelvic Peritonitis*, p. 1072.

In infancy, intestinal obstruction is set up by some congenital malformation; in childhood, commonly by intussusception; about puberty, by bands produced by peritonitis, tuberculous or otherwise, or by troubles connected with the appendix or Meckel's diverticulum. In middle life, besides the last mentioned, internal hernia, volvulus, and impaction by gall-stones may be expected. In older patients the obstruction is more likely to be malignant in origin, unless due to fæcal impaction.

Before proceeding to a separate consideration of the conditions above enumerated, an account of the symptoms, diagnosis, and treatment of intestinal obstruction in general will be given.

The **symptoms** of intestinal obstruction vary according to the

pathological conditions upon which the obstruction depends. The symptoms common to all may be said generally to be pain, vomiting, constipation, and more or less distension of the abdomen. When the *obstruction occurs suddenly*, and is attended by *strangulation* of a portion of intestine, as in 1, the various forms of constriction produced by bands; 2, a portion of intestine slipping through a hole in the mesentery or omentum, or into a retro-peritoneal pouch; 3, volvulus; and 4, external strangulated hernia, the symptoms are also *sudden* in their onset and *acute* in their course, as is likewise generally the case when they depend upon intussusception, the impaction of a gall-stone or other foreign body, the sudden accumulation of fæces above a stricture, appendicitis or peri-typhlitis, or acute enteritis or perforative peritonitis. Thus the pain is severe and violent, occurs suddenly in a person in previously good health, and is generally referred to the umbilicus, *i.e.*, about the region of the solar plexus; the vomiting comes on early, and may rapidly become fæcal; the constipation is complete from the first; flatus will not pass by the anus; the urine may be scanty and high-coloured or suppressed; there is frequently hiccough and tympanites; the temperature is below normal; the pulse rapid and feeble; the tongue is coated, and soon becomes dry and brown; the face is pale and bathed in cold sweat; the collapse increases; and the patient dies of septic poisoning. When, on the other hand, the *obstruction comes on more slowly*, and a portion of the intestine is *obstructed* rather than *strangulated*, as from (1) progressive stricture of the rectum or colon; (2) the pressure of an abdominal or pelvic tumour; (3) the gluing together of the intestines by chronic peritonitis or cancer; (4) the gradual accumulation of fæces, due to habitual constipation; and (5) chronic intussusception; the symptoms are also *insidious* in their onset and *chronic* in their course. Thus, obscure abdominal symptoms may have existed for some time. The pain is less severe, more diffused, and may be intermittent, but increases with the distension. Vomiting only occurs late in the course of the affection, and does not become fæcal till towards the last. Constipation is not complete at first, the motions may be scybalous, and there may be a history of alternating constipation and diarrhœa. The distension of the abdomen is gradual and is, perhaps, more marked in the lumbar and epigastric regions. The abdomen appears broad, and coils of intestine may be visible owing to increased peristalsis consequent upon hypertrophy of their muscular coat; gurgling sounds are often heard on auscultation. The urine is normal. Several similar attacks may have occurred, with periods of quiescence, in which the patient is apparently quite well. A stricture may perhaps be felt in the rectum by the finger, or in the sigmoid flexure by passing the hand, or a tumour may be discovered. Collapse does not come on till the end. Such, broadly, may be said to be the symptoms attending acute and chronic

intestinal obstruction. But it must not be forgotten that the conditions which commonly give rise to chronic symptoms may, at any time, suddenly terminate in complete obstruction and strangulation, when the symptoms will at once become acute. Thus a slowly contracting stricture may become suddenly obstructed by the impaction of fæces, or by a portion of intestine immediately above becoming invaginated into it, or acute peritonitis may suddenly supervene, owing to the giving way of an ulcerated portion of intestine above a stricture, &c.

The **diagnosis** of the various pathological conditions causing obstruction or strangulation of the intestines, though sometimes comparatively easy, is often very difficult, or even impossible. The surgeon's first care, when called to a patient with signs of acute abdominal obstruction, *i.e.*, pain, vomiting, constipation, and possibly distension of the abdomen, should be to exclude external strangulated hernia, not merely contenting himself with examining the femoral and inguinal rings, but also making a careful search in the less common situations of hernia, as the obturator foramen and sciatic notch. Should there be any fulness, or the least suspicion of strangulation in any of these regions, an exploratory incision should be made. Having satisfied himself of the absence of external hernia, he should next carefully examine the abdomen by inspection, palpation, percussion, and auscultation with the phonendoscope, and explore the rectum and vagina with the finger; whilst the former canal may, in some instances, be further examined by carefully passing a long enema-tube or even by introducing the whole hand. At times something may be learnt by cautiously inflating the colon with air, or by slowly distending it by the fountain syringe with fluid, the patient being in the genupectoral position. Senn has shown that gas will pass the ileocæcal valve, causing, as it does so, a distinct rushing sound, with diminution of pressure as indicated by the mercurial manometer attached to the inflating rubber-bag. If there is no obstruction the gas can be forced through the whole intestine and out at the mouth. Inflation, however, is highly dangerous, in that rupture of the intestine may easily be caused. It is rarely or never used in this country. Should (*a*) a hernia be discovered exhibiting well-marked local signs of strangulation; or (*b*) a distinct tumour be detected in the abdomen or pelvis; or (*c*) on introducing the finger into the rectum a stricture be felt; or (*d*) the bowel be found loaded with hardened fæces; or (*e*) blood and slime escape from the anus and a sausage-shaped tumour be detected in the abdomen or rectum; or (*f*) a localised and tender swelling be discovered in the right iliac fossa, the diagnosis of (*a*) strangulated hernia, (*b*) a new growth obstructing the bowel, (*c*) stricture of the rectum, (*d*) impaction of hardened fæces, (*e*) intussusception, or (*f*) appendicitis or peri-typhlitis, respectively can be readily made. But when, on the other hand, the hernial rings are

found free, the rectum empty, and nothing can be felt in the abdomen, the difficulty of localising the cause of the obstruction is great, and even after the most careful examination and thoughtful consideration of the symptoms, it may only be possible to arrive at an approximate guess as to the nature of the case. Thus, if the symptoms are acute the obstruction will probably be due to some form of internal strangulation or to a volvulus; but it must not be lost sight of that it may be due to appendicitis or peri-typhlitis, acute enteritis, or peritonitis, or possibly to the impaction of a gall-stone. If the symptoms are chronic it may be due to stricture in the upper part of the rectum or some part of the colon, malignant disease of the omentum or intestine, or chronic peritonitis. If acute symptoms have been engrafted on chronic, it may then be caused by the impaction of fæces above a stricture, peritonitis following perforation above a stricture, the giving way of a distended vermiform appendix, or the rupture of a peri-typhlitic abscess. Although it may be impossible to make a diagnosis, the following considerations may help us. Thus, if the onset of the symptoms is sudden and the patient is an infant or a young child, the cause of the obstruction will probably be intussusception or peritonitis. If the patient is elderly or middle-aged, and the symptoms are chronic, malignant stricture or impaction of fæces is the most probable cause. In middle age intussusception is rare. The tendency to vomit is in proportion to the nearness of the obstruction to the stomach, the tightness of the constriction, and the persistence with which food or fluid has been taken by the mouth. Early vomiting implies tightness of the stricture; violent retching or bile-vomiting points to gall-stones; fæcal vomiting only occurs when the obstruction is moderately low down. Vomiting may be absent at first in obstruction of the colon or rectum. Finally, if peristalsis is visible, the case is almost certainly not one of acute peritonitis.

Termination of intestinal obstruction.—Whatever the cause of the obstruction, the intestine above becomes sooner or later enormously distended with fæcal fluid (Fig. 424) and flatus, and if the obstruction be not removed the case will end fatally from exhaustion, peritonitis, ulceration or rupture, followed by collapse and peritonitis, or septic poisoning by the toxines of the *Bacillus coli communis* (*Coli bacillosis*). When rupture occurs it is usually the cæcum that becomes most distended and gives way, the rupture being in some cases preceded by superficial ulceration (*stercoral ulcers*).

Treatment.—Supposing any of the above conditions to have been diagnosed with tolerable certainty, the indications for treatment will be clear (see below). Where no diagnosis, however, can be made, the treatment may at first be expectant, but no long delay is admissible if surgery is to have a fair chance of saving the patient. Thus in *acute cases*, no food should be given by the mouth, but per rectum. A pint of warm water by the mouth being returned by vomiting will serve

to wash out the stomach and comfort the patient. Subcutaneous injections of morphia should be entirely withheld since the relief they give is only deceptive, and valuable time is thus lost. When the patient is much collapsed he should have an enema of brandy (ʒj.) and milk (ʒiij.), and be well wrapped up in hot blankets, and surrounded by hot bottles. He may also have an enema of hot water, which may either bring away fæces or be absorbed, and so help to restore the blood-pressure. The surgeon will now do well to follow the advice of the late Mr. Greig Smith, namely, to sit by the patient for half-an-hour or so. "As the shock passes off," says that surgeon, "the natural evolution of special signs comes on. These are carefully and patiently observed by sight, touch, and hearing, and their interpretation is the diagnosis. But their evolution being slow and complex, and their meaning often obscure, he must wait while they repeat themselves again and again, and not leave the patient's side till solid reasons have been found for a definite line of treatment." Having arrived at a diagnosis, or a sufficiently approximate diagnosis, the surgeon may now proceed to deal with the case as set forth in the special sections on the subject, but if the diagnosis still remains doubtful, and the patient's condition continues such that he would probably not bear the shock attending exploration, a small incision may be made through the abdominal wall, and the first piece of distended intestine that presents secured to the edges of the wound, and opened (*Enterotomy*). Later, when the distension has been relieved, and the patient's condition has improved, means may be taken for dealing radically with the cause of the obstruction.

In *chronic cases*, the diet should be restricted only small quantities of the most digestible food being given at a time, and as soon as a diagnosis can be made, measures should of course be taken for relieving, if practicable, the obstruction.

Laparotomy, abdominal section, or opening the abdomen, is an operation that may be required for the purpose of exploration in doubtful cases of intestinal obstruction, or for the relief of volvulus, strangulation of the intestines by bands or diverticula, intussusception, reduction of hernia *en masse*, &c. The room should be at a temperature between 70° and 80° Fahr., and the patient, with the limbs wrapped in cotton-wool bandages, placed on a rubber bed filled with hot water. The greatest care should be taken that nothing septic comes in contact with the wound or peritoneal cavity. Some surgeons recommend that the stomach be irrigated with warm water before giving the anæsthetic. This prevents vomiting, and may remove some of the contents of the upper part of the intestine and relieve distension, but it is apt to distress the patient or even cause collapse. Other surgeons give a hypodermic injection of $\frac{1}{100}$th of a grain of atropine, and a rectal enema of brandy to increase the heart's action. In cleansing the abdomen great care should be taken to

thoroughly disinfect the umbilicus, and the pubic hair should be shaved off (see p. 181). Make an incision in the middle line of the abdomen, midway between the pubes and umbilicus (Fig. 407, A), and having rapidly exposed the peritoneum and stopped all hæmorrhage, carefully open the peritoneal cavity on a director, or with scissors protected by the finger. If the diagnosis is still doubtful the incision should be limited to admit at first one or two fingers, or long enough to admit at once the whole hand. If a distended loop presents in the wound the obstruction is probably in the large or lower portion of the small intestine; if this loop contains fluid fæces and gas, it is probably near the obstruction; if only gas some distance off. Pass one or two fingers or the whole hand into the abdominal cavity and first explore the hernial rings from within, and if these are free the region of the cæcum, taking care to prevent the intestines from protruding by placing over them a warm flat aseptic sponge. If the cæcum is found distended, the obstruction must be in the large intestine. Carry your fingers or hand, therefore, along the course of the colon until the obstruction is met with. If, on the other hand, the cæcum is empty, the obstruction must be in the small intestine. Pass your fingers or hand in this case into the pelvis, and search for an empty loop of intestine below the obstruction and follow the intestine by passing it through the fingers piece by piece till the obstruction is discovered. If after a search of some minutes the obstruction is not found, enlarge the wound and allow the intestines to prolapse, keeping them warm by the continual application of aseptic gauze or towels wrung out of hot boiled water. When the intestines are much distended Mr. Greig Smith advised that the distended loop should be drawn into the wound, punctured with a Spencer Wells's ascites needle connected with an aspirator bottle, the distension relieved, and the little wound sutured, the surgeon waiting for hours at the bedside if necessary, and aspirating occasionally till the distension is relieved, the gut in the meantime being kept in contact with the wound by an aseptic skewer passed under it through the mesentery. Most surgeons, however, would tie a Paul's tube (Fig. 423) in the distended loop, and so allow the contents to drain quietly away. To do this the gut is drawn into the wound, packed round with aseptic gauze or sponges to protect the peritoneum, an incision large enough to admit the tube made, the tube (previously plugged with wool) inserted, and fixed by a ligature passed round the flange. The plug of wool is then removed and rubber tubing fixed to the distal end of the tube to convey away

FIG. 423.—Paul's glass tubes for draining the intestine. The end with the double flange is inserted and tied in the gut. (After Paul.)

the fæces. After the distension is relieved the case must be treated as circumstances suggest.

Treatment of the various conditions that may be met with in laparotomy.—When dealing with any of the following conditions great care should be taken to prevent soiling of the peritoneum with septic or fæcal material by well packing around the seat of operation with aseptic sponges or gauze, and shock should be minimised as much as possible by performing the necessary operation with as much despatch as is consistent with thorough work. (*a*) If a *loop of intestine* is found *strangulated* in one of the hernial rings, in a hole in the mesentery, or in a retro-peritoneal pouch, it must be released from within the abdomen, dividing any stricture if necessary. (*b*) If a *volvulus* is discovered an attempt must be made to untwist it, and as a prophylactic against retwisting, the mesentery may be shortened by folding it upon itself parallel to the intestine and fixing it with sutures. If the volvulus cannot be reduced, the contents may be let out, the wound sutured, and another attempt made. This failing, the volvulus may be excised and the intestine restored by one of the methods of enterorrhaphy (p. 533). If the patient is too collapsed to admit of excision, the volvulus may be left and the intestine short-circuited by means of a Murphy's button or by one of the other methods described at p. 545. If gangrene has occurred, the volvulus must be excised and circular enterorrhaphy or lateral approximation performed. (*c*) If a *band* is met with it must be divided. (*d*) If a *large diverticulum* is the cause of the obstruction it must be cut across and the bowel end closed by Halsted's or Lembert's suture. (*e*) If a *small diverticulum* is producing the constriction it must be severed and the two ends ligatured in the way described for removing the appendix. Should the intestine give way in dividing the obstructing bands, etc., or have already given way—if the perforation is small and the coats are in a fairly healthy condition, the wound in the intestine may be closed by sutures in the way described under *Wounds of the Intestine*. But if the coats are in an inflamed or sloughy condition, or gangrenous, the diseased portion may be excised, and the upper and lower portions of the intestine united in one or other of the ways already mentioned (p. 537). Only when the patient is much collapsed should the ends of the bowel be fixed to the external wound and an artificial anus made. Before uniting the intestine, however, it may be well in some cases to fix the intestine temporarily in the wound and let the contents of the distended portion drain away for several hours or even days. (*f*) If an *intussusception* is discovered, it is treated as described on p. 874. (*g*) If a *gangrenous* or *perforated* appendix or a *peri-typhlitic abscess* is met with it may be treated as described at p. 891. If diffuse septic peritonitis is present it may be dealt with in the way mentioned below and at p. 552.

Cleansing of the peritoneum.—After any of the above operations,

carefully cleanse the abdomen from blood by gentle sponging, especially the pelvis, ileo-cæcal fossa, or other pouch if involved, and close the wound in the parietes by uniting the peritoneum, muscles and aponeurosis and skin by separate rows of sutures. If in spite of all care the peritoneum has been soiled by fæcal matter, or septic changes have already started—if the soiling is *local*, carefully clean by sponging with an antiseptic lotion the affected part, cautiously avoiding flushing as this might carry the septic material into as yet healthy portions of the general peritoneal cavity. If, however, the *general peritoneum* is already infected, flush out the cavity with gallons of sterilised hot water (105° F.) or hot water to which salt (3j. to Oj.), or some antiseptic as salicylic acid (5 per cent.) or boracic acid (2 per cent.) has been added. In flushing out, pass the irrigating tube amongst the intestines to the back of the abdominal cavity and into the pelvis so that the water may flow outwards, or if a tube is not at hand pour in the solution from jugs or cans. If the intestines have been allowed to prolapse there may be some difficulty in getting them back. Cover them with antiseptic gauze wrung out of hot water, tucking the margins of the gauze beneath the edges of the wound. Introduce the sutures, and when they are all *in situ* make uniform pressure on the gauze as the sutures are tightened and tied from above downwards. Withdraw the gauze before the last sutures are tied. Drawing forward the edges of the wound with retractors will materially aid the replacement of the intestines. If they cannot be replaced draw a distended loop away from the wound, aspirate or open it, evacuate as much of the contents as possible, suture the wound by Lembert's method, and again endeavour to replace the prolapsed intestines. When fæcal soiling or septic changes have occurred, place a glass drainage tube in the wound (see *Ovariotomy*), or loosely pack with strips of iodoform gauze or with iodoform gauze rolled up in the shape of a lamp wick and encircled by a layer of gutta-percha tissue with holes cut in it. The end of the drain should be surrounded by plenty of dry gauze to suck up the fluid. In some cases when the pelvis and renal fossæ have been soiled, openings may be made above the pubes and in the loins and drainage employed in these situations as well.

After-treatment of laparotomy.—For the first twelve to twenty-four hours nothing should be given by the mouth, except teaspoonfuls of hot water to allay sickness, but nutrient enemata (consisting of beef-tea or bovril ʒij., milk ʒj., peptonising powder 3j.) may be administered. Later, teaspoonfuls of milk or milk and water should be taken every two hours, and be gradually increased in amount. To the milk plasmon (3j.) may be added with advantage. Still later beef-tea, mutton-broth, jelly, and Benger's food may be added to the dietary, and after three or four days minced chicken, minced chop, etc. If there is much shock strychnine (gr. $\frac{1}{80}$) may

be injected subcutaneously, and brandy be added to the enemata and cautiously given by the mouth. The bowels, if they do not act spontaneously, should be opened by an enema or dose of Epsom salts or castor-oil before the fifth day. If there is much distension of the abdomen the flatus should be drawn off by the long enema tube, or an enema of turpentine (turpentine ℥j., gruel Oj.) may be given.

Enterotomy, or Nélaton's operation, consists in opening the abdomen by a short incision in the middle line or in the right or left groin, seizing the first piece of distended intestine that presents, drawing it into the wound and then opening it in the way described at p. 862. This operation is employed in cases where the obstruction is believed to be in the small intestine though the diagnosis of the situation is uncertain, and where the patient's condition is such that the severe shock and the prolonged manipulation that necessarily attends laparotomy (the operation otherwise indicated) would probably be fatal. It may also be employed in cases of obstruction due to contractions consequent upon the matting together of the small intestines from chronic inflammation, cancer, etc. It should be thoroughly understood, however, that the operation is only intended to relieve the distension of the intestines and prevent their rupture. It does not attack the seat of obstruction. But, by relieving the acute symptoms, it may give time for a diagnosis in doubtful cases to be arrived at; and the patient's condition after it may so far improve as to allow of a more radical course of treatment being undertaken on a future occasion.

Intestinal anastomosis is the formation of a union between the gut above and below the obstruction, short circuiting the contents. It may be performed by suture or by Murphy's button (see p. 545). The ileum or ascending or transverse colon may be joined to the sigmoid flexure, etc.

Enterectomy consists in opening the abdomen and excising a portion of the intestine. It may be required for irreducible intussusception, carcinomatous stricture, gangrene from strangulation by bands, etc., the closure of fæcal fistulæ, wounds of the intestine, etc. Open the abdomen as in laparotomy; draw the portion of intestine to be removed well out of the wound, and pack it round with sponges or antiseptic gauze; clamp the intestine above and below to prevent the escape of fæces with Makins' clamp, or with a safety pin and sponge or with a rubber tube passed through a small incision in the mesentery, or an efficient assistant may prevent any escape with his fingers; cut out the diseased or damaged part; tie all bleeding vessels; carefully unite the mesentery, if a wedge-shaped piece has been removed, with sutures; and then join the intestine by one of the methods already described (p. 537). The length of intestine removed must be enough to allow the union of perfectly healthy gut. The resection may involve more than a foot without harm.

superior spines of the ilium. Make an incision about four inches long between the last rib and crest of the ilium from the erector spinæ obliquely outwards and downwards. Divide the skin, fascia, and various layers of muscles, viz., the latissimus dorsi, external oblique, internal oblique, and transversalis, and the transversalis fascia (Fig. 425); the quadratus lumborum will now be exposed at the inner part of the wound, and may be known by its fibres running upwards and inwards. When the colon is distended it may bulge in the wound; when contracted, however, it may be sought in the wound by carefully scratching through the fatty tissue covering it, with two pairs of dissecting forceps. If there is much difficulty in finding it, pass *per rectum* a small catheter, if practicable, through the stricture, and inflate the colon. The colon may be distinguished from the peritoneum, which sometimes presents in the wound, by its situation immediately external to the quadratus lumborum and below the kidney; by the presence of a longitudinal band of muscular fibres; by the thickness of its coats on nipping it up by the fingers; and, at times, by in this way feeling scybalous masses of fæces in its interior. The peritoneum, on the other hand, may generally be known by the absence of the above characters, and, if it is nipped up, by the intestine being felt to slip away from between the fingers. Having found the colon, secure it to the skin. This is usually done by passing a silk suture by means of a curved needle on a handle, first through the skin, then through the bowel, and then through the skin on the opposite side of the wound, and repeating the procedure at the other end of the wound. The bowel is then opened in a longitudinal direction, the loops of suture by which it is transfixed hooked out by the finger and divided, and the bowel secured to the integument by the four sutures thus formed. A better and more convenient way of passing the sutures, which should then be of wire, is by Smith's cleft-palate needle. If this is used a series of sutures are passed, first through the skin, and then through the wall of the bowel, and tied before the bowel is opened. Should the peritoneal cavity be opened by mistake, it must be accurately closed by suture before the incision is made into the colon.

Fig. 425.—Diagram of parts divided in left lumbar colotomy.

Some perform lumbar colotomy in two stages, like gastrostomy; but if the operation is carefully done in the way described above, such is hardly necessary. The bowel beyond the wound may subsequently require washing out from above downwards. Indeed, it has been proposed to close completely this part of the bowel by operation so as to prevent fæces passing down it.

colon, draw it down until the mesocolon is taut, so as to avoid prolapse of the bowel subsequent to the operation. Bring a small loop of the bowel well out of the wound, pass a piece of glass rod or a Koeberle's hysterectomy pin beneath it through the mesocolon so as to produce a good spur and thus prevent the fæces going down the distal end of the intestine, and further secure the gut by a suture carried across each end of the wound through all the parietal tissues, but through only the peritoneal and muscular coats of the gut. Apply an antiseptic dressing with a piece of protective next the bowel to prevent its adhering to the gauze, and at the end of three to five days, when adhesions have had time to form, cautiously open the gut by cutting through it on to the glass rod or pin. Some surgeons, for the purpose of forming a spur, draw the gut forward by a ligature passed through the mesentery and abdominal wall. When the peritoneum contains fluid the adhesions between the bowel and parietes are apt to be impaired, especially if the old method of uniting the peritoneum to the skin is employed, and the gut may suddenly slip back into the peritoneal cavity. To prevent this untoward event the rod or pin should be kept *in situ* for ten days or longer, if, at the operation, fluid is found. In a few cases a loop of small intestine has escaped during a fit of coughing between the colon and the edge of the wound in the parietes, an accident that may be guarded against by avoiding too long a wound. No food should be given by the mouth for the first twelve to twenty-four hours, and then slop diet until the gut is opened. If the bowel is greatly distended at the time of operation and threatening to burst, it may be opened at once, tying in a Paul's tube; or should vomiting and distension come on after the operation, it may be opened before the usual three to five days have elapsed. Some surgeons give opium as a routine practice, but it is better to withhold it unless there is pain or restlessness. If the bowel does not act spontaneously after the gut has been opened, a gentle saline purge or an enema may later become necessary. The bowel below the wound may also require washing out from above downwards.

Lumbar colostomy, or colotomy, is the opening of the colon in the left lumbar region (*Callisen's operation*), or in the right (*Amussat's operation*). These operations are not often done at the present day, the inguinal method being preferred. The former is chosen when the disease occurs in the rectum or lower part of the sigmoid flexure; the latter when there is any doubt whether it may not be in the transverse colon. That on the left side need only be described. Place the patient on his right side, slightly inclining towards his face, with pillows under the abdomen, or beneath the loin, in order to make the left side prominent. The outer border of the quadratus lumborum, the guide to the colon, should then be marked: it is situated half an inch posterior to a line drawn vertically upwards from a point midway between the anterior superior and posterior

superior spines of the ilium. Make an incision about four inches long between the last rib and crest of the ilium from the erector spinæ obliquely outwards and downwards. Divide the skin, fascia, and various layers of muscles, viz., the latissimus dorsi, external oblique, internal oblique, and transversalis, and the transversalis fascia (Fig. 425); the quadratus lumborum will now be exposed at the inner part of the wound, and may be known by its fibres running upwards and inwards. When the colon is distended it may bulge in the wound; when contracted, however, it may be sought in the wound by carefully scratching through the fatty tissue covering it, with two pairs of dissecting forceps. If there is much difficulty in finding it, pass *per rectum* a small catheter, if practicable, through the stricture, and inflate the colon. The colon may be distinguished from the peritoneum, which sometimes presents in the wound, by its situation immediately external to the quadratus lumborum and below the kidney; by the presence of a longitudinal band of muscular fibres; by the thickness of its coats on nipping it up by the fingers; and, at times, by in this way feeling scybalous masses of fæces in its interior. The peritoneum, on the other hand, may generally be known by the absence of the above characters, and, if it is nipped up, by the intestine being felt to slip away from between the fingers. Having found the colon, secure it to the skin. This is usually done by passing a silk suture by means of a curved needle on a handle, first through the skin, then through the bowel, and then through the skin on the opposite side of the wound, and repeating the procedure at the other end of the wound. The bowel is then opened in a longitudinal direction, the loops of suture by which it is transfixed hooked out by the finger and divided, and the bowel secured to the integument by the four sutures thus formed. A better and more convenient way of passing the sutures, which should then be of wire, is by Smith's cleft-palate needle. If this is used a series of sutures are passed, first through the skin, and then through the wall of the bowel, and tied before the bowel is opened. Should the peritoneal cavity be opened by mistake, it must be accurately closed by suture before the incision is made into the colon.

Fig. 425.—Diagram of parts divided in left lumbar colotomy.

Some perform lumbar colotomy in two stages, like gastrostomy; but if the operation is carefully done in the way described above, such is hardly necessary. The bowel beyond the wound may subsequently require washing out from above downwards. Indeed, it has been proposed to close completely this part of the bowel by operation so as to prevent fæces passing down it.

The various conditions causing intestinal obstruction.

1. **Impaction of fæces, gall-stones, or foreign bodies in the intestines.**—An accumulation of hardened fæces may occur as the result of habitual or accidental constipation, and is then nearly always met with in the large bowel, and especially in the region of the cæcum or in the sigmoid flexure and rectum. The impaction of gall-stones or intestinal concretions, though more rare, is also met with, but usually in the small intestines. Obstruction from these causes is more common in women than in men. Foreign bodies that have been swallowed, though they usually escape at the anus, may become impacted in any part of the intestine, but especially in the lower part of the ileum, the cæcum, or rectum.

Signs.—In *impacted fæces* there may be a history of previous constipation, the rectum will probably be found distended, or fæces will be passed on the use of enemata. A swelling may be felt through the abdominal parietes, and if so will be soft, and can perhaps be indented with the fingers. In *obstruction from gall-stones*, there may be pain in the region of the gall-bladder, perhaps jaundice; gall-stones may have passed, or similar attacks have been previously suffered from, and the bowels may have acted irregularly. The vomiting is gastric or bilious, and is attended with violent retching. But in most cases there is nothing in the patient's history pointing to biliary trouble. If the obstruction is due to a *foreign body* there will probably be a history of one having been swallowed, and it may be detected by the *x* rays.

Treatment.—In *impacted fæces*, when medical means and enemata have failed, the rectum may require clearing with a scoop or other suitable instrument. In *obstruction* from impacted *gall-stones* or other foreign bodies, the abdomen is opened, and the gall-stone or foreign body removed through an incision in the intestine, or else made to pass by gentle manipulation through the ileo-cæcal valve. The incision should be made in the longitudinal axis of the gut, opposite the attachment of the mesentery, not over the impacted body, where the coats may be damaged, but a few inches higher up. The gall-stone or other body may then be removed, breaking it first if necessary, and the wound be afterwards united by Halsted's or Lembert's suture. Or should the walls of the gut be softened by ulceration, a portion of the intestine may be resected, and the continuity of the tube restored by one of the methods of enterorrhaphy described at p. 537. An impacted gall-stone may sometimes be broken up with a needle without opening the intestine.

2. **Internal strangulation or internal hernia.**—These terms are applied to obstruction of the intestine by some constricting agent within the abdomen. The strangulation may be effected by: 1. Bands produced by the stretching of old inflammatory adhesions, the result of former peritonitis. These are more particularly

common about the mouths of old hernial sacs. 2. The remains of some fœtal structure, as the omphalo-mesenteric duct (Meckel's diverticulum), etc. 3. A coil of intestine slipping through a hole in the mesentery or omentum. 4. A coil of intestine passing into a pouch of peritoneum (*retroperitoneal hernia*) such as the duodeno-jejunal, the sigmoid, or one of the ileo-cæcal pouches, or through the foramen of Winslow into the lesser peritoneal cavity.

Symptoms.—In *internal strangulation* the attack is very sudden and is probably attributed to a strain; the pain is intense, and is referred to one spot, or to the umbilicus; vomiting comes on early and gives no relief; the constipation is sudden; there is no desire to defæcate; the urine is scanty; there is no visible peristalsis; no tumour can be felt; there is no hæmorrhage from the bowel, and no tenesmus; the abdominal walls are very tense. There is probably a history of some affection which might produce bands of adhesions, as peritonitis, typhoid fever, or a former hernia; or there may have been previous attacks of abdominal obstruction with intervals of perfect health.

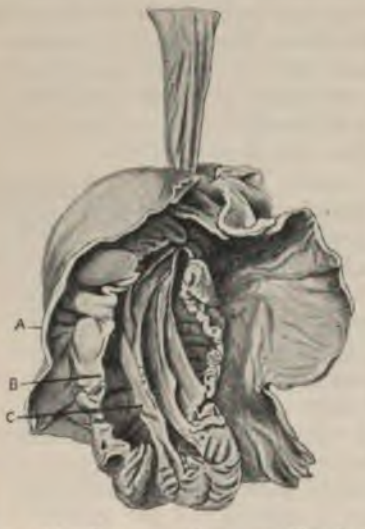


FIG. 426.—Intussusception. A, Sheath or intussuscipiens. B, Middle or returning tube. C, Innermost or entering tube. (St. Bartholomew's Hospital Museum, No. 2182.)

Treatment. — Abdominal section is the only procedure of any avail, and ought, like herniotomy, to be undertaken early and not merely as a last resource (see *Laparotomy*).

3. **Volvulus** is a twisting or kinking of a coil of intestine, so that its calibre is completely obliterated at the twisted or bent spot. Accumulation of flatus, excessive peristalsis due to gall-stones, constipation and unequal distension have been assigned as causes. Volvulus is said to be most common in the sigmoid flexure, and always to be situated towards the back of the abdominal cavity. The intestine may be—1, simply bent upon itself; 2, twisted round its mesentery; and 3, wound round another coil of intestine. The first form only occurs in the colon; the second in the small intestine; the third form usually consists of the colon wound round a coil of small intestine, the sigmoid flexure, or the cæcum.

The *signs* are similar to those of internal strangulation, but if anything still more severe. Meteorism, or distension with gas,

comes on early and is well marked. The patient is probably over forty years of age, and has suffered from constipation. The distended sigmoid flexure may be visible. There may be some tenesmus or straining to pass a motion and the vomiting may relieve for a time. But besides the general signs of intestinal obstruction a diagnosis before operation can hardly ever be made.

Treatment.—No time should be lost in opening the abdomen (see *Laparotomy*). The coil of intestine should be untwisted and be fixed in position by suture; if gangrenous the choice lies between excision and colotomy.

4. **Intussusception** (Fig. 426) is the invagination of a portion of intestine into the lumen of the intestine immediately below. The intestine thus forms three tubes, one within the other, an outer,

Fig. 427. — Intussusception. (St. Bartholomew's Hospital Museum.)

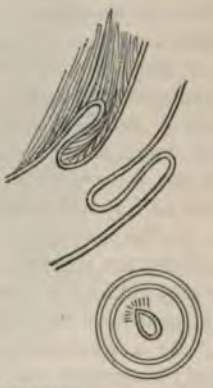


Fig. 428.—Diagram of intussusception to show the three tubes and the drawing in of the mesentery between the inner and middle tube.

middle, and inner (Fig. 428). The external tube is called the *sheath*, or *intussuscipiens* (Fig. 426, A), the innermost the entering tube (Fig. 426, C), the middle the receding, returning, or inverted tube (Fig. 426, B), the last two together being further called the intussuscepted portion, or *intussusceptum*. Thus there are two peritoneal and two mucous surfaces of the intestine in contact (Fig. 428), and between the inner and middle tubes is a portion of the mesentery or mesocolon, which is necessarily drawn down with the intestine. The dragging of the mesentery causes the intussusceptum to assume a greater curve than its sheath, and hence to become puckered along its concavity; it also causes the orifice of the intussusceptum to be directed towards the mesenteric attachment and to be slit-like in shape (Fig. 427). The intussusception nearly always increases at the expense of the lower portion of the intestine, the intussuscipiens or sheath becoming more and more infolded, so

that, if the intussusception occurs at the ileo-colic junction, no more of the ileum will be involved, but the cæcum and colon may be gradually folded in. More rarely, however, the ileum is protruded through the ileo-cæcal valve; the intussusception then increases at the expense of the upper portion of the intestine, more and more of the ileum being protruded through the valve. Four chief kinds of intussusception are described. 1. The *ileo-cæcal*, the commonest form, in which the ileum and cæcum protrude into the colon, the ileo-cæcal valve forming the apex of the intussuscep*tum*, more and more of the *colon* being folded in. 2. The *ileo-colic*, the least common, in which the ileum protrudes through the ileo-cæcal valve, the ileum forming the apex of the intussuscep*tum*, but the part of the ileum forming the apex keeps changing as more and more of the *ileum* passes through the valve. 3. The *colic*, in which part of the colon is invaginated into the colon below; and 4. The *enteric*, in which a portion of the small intestine is invaginated into a lower part of that bowel. At first the invagination is reducible, and is not attended with any serious obstruction to the lumen of the intestine. In this condition it may remain, in chronic cases, for several weeks or months. Or the mucous membrane of the intussuscep*tum* may become congested and swollen, rendering reduction difficult or impossible without rupture or other injury of the intestine. In the majority of cases, however, especially in infants, if the intussusception is not soon relieved, the blood-vessels of the involuted mesentery rapidly become constricted where the latter enters the sheath, causing acute obstruction to the circulation in the receding tube. As a consequence of this, the mucous membrane becomes intensely congested, and pours out the sanious discharge so diagnostic of the disease. In the meanwhile the contiguous peritoneal surfaces of the inner and middle tube become inflamed and glued together, rendering reduction impossible. Gangrene of the intussuscep*tum* now ensues, and the patient usually dies of collapse or peritonitis in a few days. In adults, however, and in children of six or eight years and upwards, the gangrenous portion may very occasionally slough off at the constricted part and be passed per anum; but in children under two years of age the disease, unless relieved by treatment, is almost invariably fatal. Should recovery take place in this manner, the patient may subsequently succumb to stricture of the intestine, from contraction occurring at the spot where the intestine has united. The intussusception may measure only two or three inches in length, or it may involve a great part (Fig. 429) or the whole of the large intestine and protrude at the anus. Its most common situation is at the ileo-colic junction, then in the small intestine, and then in the colon; at the ileo-colic junction the ileo-cæcal variety is very common, the ileo-colic is rare. Intussusception is rare in adults but common in children, especially in infants. In 75 per cent. of the cases admitted into St. Bartholomew's

Hospital during a period of ten years the patient was under one year of age. The reasons given for the affection being so common in young children are the greater length of the mesentery in childhood, and the rapid increase in the size of the colon as compared with the ileum soon after birth. It has been shown that peristalsis stops at the ileo-cæcal valve, whilst fresh peristalsis occurs in the colon. It may thus happen, especially during irregular peristalsis, such as may be set up by castor-oil, injudicious feeding, diarrhœa, worms, or external violence, that the ileum may be contracting at a

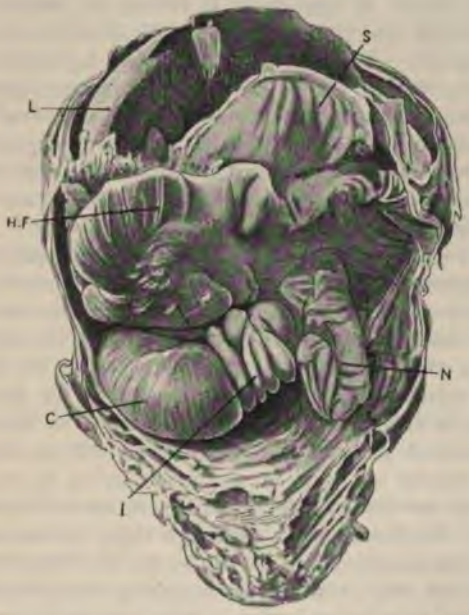


FIG. 429.—Intussusception. C, Ascending colon. I, Ileum. L. Liver. S. Stomach. H.F. Hepatic flexure of colon containing apex of the intussusceptum. N. Jejunum. (St Bartholomew's Hospital Museum, No. 2182 *b*.)

time when the colon is dilated to its greatest extent, and so gets slightly tucked into the larger bowel, and then when the colon contracts, is violently seized and "swallowed," as it has been aptly termed, the long mesentery of childhood favouring the invagination. In some cases, especially adults, the invagination has apparently been due to the dragging of a polypus. The slight invaginations, often multiple, of the small intestine which may occur in the dying, must not be mistaken for true intussusceptions. In these the lower part of the intestine is often invaginated into that above. Very occasionally such multiple intussusceptions have been met with during life with the lower part of the gut invaginated into the upper.

Signs.—When the *intussusception* is *acute*, there is a discharge of mucus and blood from the anus with usually marked tenesmus; the pain is intermittent and comes on in spasms; the abdomen is not much distended; meteorism is absent; the abdominal parietes are usually lax, and through them a sausage-shaped tumour, doughy to the feel, hardening on handling, and perhaps changing its position from time to time, may sometimes be detected, and most usually on the left side. The invaginated bowel can possibly be felt in the rectum. In the ileo-cæcal form the resistance in the right iliac fossa may be decreased (*signe de Dance*) owing to the cæcum, as more and more of the colon is folded in, passing across the abdomen through the transverse into the descending colon. Collapse soon ensues. When *chronic*, there may have been attacks of localised pain lasting for months before strangulation occurs, the patient having been in good health in the intervals. There is straining and tenesmus; the constipation is not complete; vomiting is absent or intermittent; the distension is not marked; and collapse does not come on till the end. The tumour will have characters similar to those mentioned above.

Treatment.—When the *intussusception* is *acute*, laparotomy should at once be performed (see *Laparotomy*). Time should not be lost in trying injections and insufflation, lest the bowel become so damaged or the intussuscep*tum* so adherent to the intussuscip*iens* as to render the prospect of success hopeless. We have come to the definite conclusion that unless laparotomy for intussusception in an infant is undertaken within twenty-four to thirty-six hours from the onset of the symptoms, reduction will be found next to impossible without so injuring the intestine as to render a fatal result almost inevitable, whereas the best results follow an early laparotomy. In *chronic* cases, although there is less need for early operative interference than in acute, as the bowel may remain incarcerated for some time before becoming strangulated, it should not be delayed too long, lest the intussuscepted portion become adherent to the sheath. Should it appear probable that this has already happened, two courses are open: either to open the abdomen, or to keep the patient under the influence of opium in the hope that the intussusceptum may slough off and be passed *per anum*. In exceptional cases of intussusception of the sigmoid flexure the mass may be drawn out of the anus, the gut above and below united by sutures, the intussuscep*tum* cut away, and the united gut reduced.

The abdomen having been opened by a median incision, and the intussusception discovered and drawn into the wound, first squeeze out some of the inflammatory œdema by steady uninterrupted manual compression with an aseptic sponge, and endeavour to reduce the intussusception by gentle traction on the bowel just above the neck of the intussuscipiens and by counter-traction just below the apex of

the intussusceptum; or better, try to squeeze out the intussusceptum by kneading and pressure from below. Reduction may, it is said, be aided by insufflation of the rectum with air or hydrogen. If adhesions have formed, try to break them down by gently insinuating a probe between the contiguous serous surfaces. After reduction search for any rent in the peritoneal coat and bring it together by suture and seal with an omental graft (Fig. 216, p. 539). Reduction failing, the following courses are open:—1. Excision of the intussuscep*tum* by making an incision in the sheath, drawing the intussusceptum through, cutting it off, and uniting the bowel after Maunsell's method (see p. 540). 2. Complete excision of the intussusception and restoration of the bowel by circular enterorrhaphy, lateral approximation, Murphy's button, etc. Complete excision is a most serious operation, especially in infants and when a long length of bowel is involved, and should be reserved for those cases in which gangrene has occurred. After reduction there is a danger of recurrence owing to the paralysed condition of the bowel which has been intussuscepted. To prevent this the coil may be sutured to the back of the abdominal wall in a suitable position.

5. **Strictures of the intestine consequent upon disease of the intestinal wall.**—This condition is generally due to the growth of a carcinoma of the intestinal wall, more rarely to contractions following dysenteric, tuberculous or syphilitic ulceration, the passage of gall-stones, or injury or operation on the intestine. It is most frequently met with in the large intestine, especially the rectum, and then in order of frequency, in the sigmoid, descending colon, splenic flexure, hepatic flexure and cæcum. It is rare in the small intestine.

Symptoms.—The patient is usually old or middle-aged; the symptoms come on very insidiously; there are alternate attacks of constipation and diarrhœa; the constipation gradually becomes more and more pronounced; the motions are probably lumpy (*scybalous*), pipe-like, or flattened; dyspepsia is complained of; the pain is diffused and depends upon the distension of the abdomen; the distension comes on slowly, and is greatest in the flanks; peristalsis is visible; the urine is copious; the pulse quiet; and vomiting only occurs late in the case. Similar attacks may have occurred from which the patient quite recovered. Having diagnosed the case as one of stricture, the next point to determine is whether it is situated in the sigmoid flexure or rectum, and consequently that opening the sigmoid flexure in the left groin or the descending colon in the left loin, will be well above the stricture; or whether it is situated in the descending colon, splenic flexure, or transverse or ascending colon, so as to necessitate the opening of the transverse colon, ascending colon or cæcum. To begin with, it should be remembered that stricture is most common in the sigmoid flexure and rectum, next in the colon, with diminishing frequency up to

the cæcum, then in the cæcum itself, and is very rare in the small intestine; indeed it is so rare in the last situation, that when its exact position is not known, it is generally safe to assume that transverse or right colotomy or typhlotomy will suffice. Again, if the stricture is in the rectum or sigmoid flexure, the distension will be equal on the two sides; when in the descending or transverse colon, greater on the right than on the left side. The amount of distension on the two sides may be more accurately estimated by the cyrtometer than by mere inspection and palpation. If an enema tube will pass for some distance, say a foot or so, and a large quantity of fluid can be injected, the stricture is probably high up; but too much importance must not be attached to this sign, as the enema-tube may have bent upon itself and the rectum and sigmoid flexure are often very capacious. Sometimes when the stricture is just above the reach of the finger the rectum becomes greatly dilated (*ballooned*), due, it is said, to paralysis of the muscular coat of the rectum following on involvement of the nerves in the cancer. Further, something may at times be learnt by auscultating the colon, especially with the aid of the phonendoscope whilst the injection is being given, and by passing a long Kelly's speculum into the rectum. The detection of a tumour in any part of the colon or cæcum will, of course, set the diagnosis at rest.

Treatment.—For *stricture of the large intestine*, left inguinal colotomy should be performed when the obstruction is in the rectum or sigmoid flexure, transverse colotomy when in the descending colon or splenic flexure, and right lumbar colotomy or typhlotomy when in the transverse colon, hepatic flexure or descending colon. If the patient's condition is fair and the bowel still sound above and below the stricture, a better result may be obtained by anastomosis between the sigmoid and the ileum or colon above the obstruction, thus avoiding an artificial anus. Should the strictured portion be readily reached in performing the operation, it may, if the disease is localised, be cut out (*colectomy*, *typhlectomy*), and the bowel secured to the wound, or the two portions of bowel united. Or better, the strictured portion may be drawn out of the wound, a Paul's tube inserted in the bowel above, and after the distension has subsided the diseased portion cut away, and the bowel above and below united and returned into the abdomen.

In *stricture of the small intestine*, under suitable conditions, enterectomy with union of the intestines by one of the methods already described is performed, if not an anastomosis, for a fæcal fistula so high up is quickly fatal from wasting.

6. **Constrictions of the intestine consequent upon disease beginning external to the intestinal wall.**—This condition may depend on chronic peritonitis, or on malignant disease of the omentum or mesentery. It is more common in the small than in the large intestine, and not only narrows the calibre of the bowel,

but also obstructs the peristaltic action by gluing the coils of intestine to one another and causing contraction of the mesentery.

Signs.—There is pain of a paroxysmal nature, of short duration and of frequent occurrence; peristalsis may not be visible on

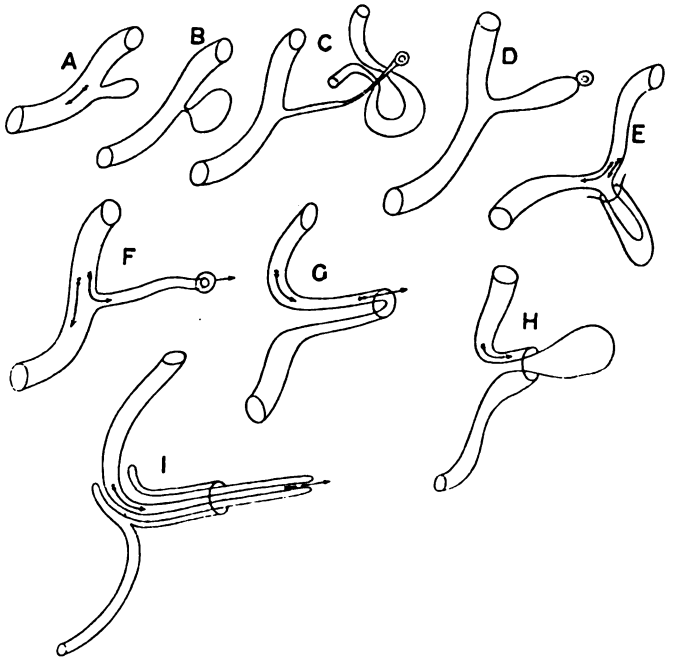


FIG. 430.—Meckel's diverticulum under its various forms. A, A small intestinal pouch, not giving rise to trouble. B, A cyst formed by narrowing of the neck of the pouch. C, The apex of the pouch remaining attached to the umbilicus so as to form a band, beneath which a coil of intestine may slip and become strangulated. D, The pouch remains patent up to the umbilicus. E, As such it may become engaged in an umbilical hernia, when the symptoms occasioned will be those of partial enterocele (p. 900). F, A patent Meckel's diverticulum, forming a fæcal fistula at the umbilicus in a newborn infant as a result of ligaturing off the cord in the condition noted under E. G, An artificial anus at the umbilicus, resulting as an extension of F by the prolapse of the wall of the ileum through the diverticulum to form a spur between two openings. H, A further prolapse of the foregoing spur forms a pedunculated tumour covered by mucous membrane, at the base of which are two orifices from one of which fæces escape. I, A complete intussusception may occur through a patent Meckel's diverticulum, resulting in a swelling at the umbilicus similar to the protrusion of an intussusception from the anus.

account of the matting together of the intestines, but gurglings may be heard. There is no vomiting or distension except during the attacks of pain. Constipation is not complete; defæcation is painless; the motions are not compressed or pipe-like as they may be in stricture; and there is no distension in the flanks. The symptoms may at any time suddenly become acute.

Treatment.—Where the intestines are matted together by chronic peritonitis or cancer, when medical means have failed, an anastomosis may sometimes prove of temporary benefit by relieving the distension.

7. **Mechanical pressure on the intestine** by innocent or malignant growths, hydatid cysts, enlarged glands, etc., may occasionally give rise to obstruction. A tumour will then be probably discovered on palpation of the abdomen or by the finger in the rectum or vagina. An exploratory operation should be undertaken, and the cause of the obstruction removed if practicable.

8. **Congenital malformations of the intestine.**—Amongst the chief of these may be mentioned imperforate anus, deficiency of the rectum, absence of the colon, termination of the colon in the bladder, etc. Obstructions from such and like causes are only met with in the infant (see *Diseases of Rectum*). The so-called idiopathic dilatation of the colon, and the persistence of the omphalo-mesenteric duct, forming what is called Meckel's diverticulum, may lead to obstructions in older persons.

The *symptoms* set up by Meckel's diverticulum are those of intestinal obstruction in a young patient, for which an immediate operation is indicated. The existence of one of the conditions at the umbilicus shown in Fig. 430 may enable a diagnosis to be formed beforehand. *Treatment.*—Meckel's diverticulum is excised in the same way as the appendix (see p. 891). In cases of artificial anus and intussusception at the umbilicus it is necessary to resect the bowel.

9. **Paralysis of the muscular coat of the intestine.**—Obstruction sometimes occurs solely as the result of loss of power in the muscular coat of the intestine (*adynamic intestinal obstruction*). This form of obstruction may be due to the excessive formation of gas during an attack of dyspepsia, to habitual constipation, etc.; or it may follow operations on the rectum. Paralysis of the muscular coat may also occur after abdominal section, an operation for strangulated hernia, etc., owing to venous congestion, and stasis and gangrene may follow.

Symptoms.—The most prominent sign is perhaps tympanites, which, as a rule, extends over all the abdomen. There is also constipation, perhaps inability to pass flatus, and, frequently, vomiting, which, in extreme cases, may become fæcal, and restlessness and pain from the abdominal distension. The presence of general tympanites, and the absence of signs of organic obstruction, and especially of peristaltic movements are the points to be chiefly relied on. In this form of obstruction the symptoms may so closely resemble those due to mechanical causes that the abdomen has frequently been opened in the belief that such existed.

Treatment.—In obstruction due to simple paralysis or inertia of the muscular coat (*adynamic obstruction*) a rectal tube should be passed to let the flatus escape if there is much distension, and so

allow the muscular coat to regain its tone, whilst medical measures should be taken to restore the loss of tone in the intestine. In the paralysis following an abdominal section or operation for strangulated hernia, a saline purge may be given to stimulate the peristalsis, unless the condition of the bowel discovered at the operation was such as to forbid its use.

10. **Gangrene from embolism and thrombosis of the mesenteric arteries and veins.**—The *obstruction of the superior mesenteric artery or vein*, or of one of their main branches, inevitably causes gangrene of the corresponding portion of the bowel. A like injury or obstruction of one of the secondary or tertiary loops may not cause gangrene, but bruising or obstruction of the smaller blood-vessels running from the terminal loops to the wall of the bowel in that there is practically no anastomosis between these vessels may do so. This obstruction may be due, in addition to injury, to atheroma affecting the aorta and to other causes of embolism and thrombosis, also to the rupture of an aneurysm. It has also followed operations unconnected with the abdomen as well as exhausting diseases. There are no marked signs of this condition, the patient appearing to be suffering from intestinal obstruction, such as is set up by internal strangulation, or paralysis of the intestines. On opening the abdomen blood-stained foul fluid escapes and the intestines are found black from venous congestion going on to gangrene. It is useless to proceed further with the operation; only when the gangrene is very limited should one attempt resection, for which healthy bowel is essential.

11. **Acute peritonitis and enteritis** are not uncommon causes of intestinal obstruction. Peritonitis is a frequent termination of the other conditions that cause obstruction, but it is perhaps most often due to inflammation spreading from the region of the cæcum (*peri-typhlitis*), the bursting of a peri-typhlitic abscess into the peritoneal cavity, to ulceration, perforation, or gangrene of the vermiform appendix or to rupture of a pyosalpinx.

Signs.—The abdomen is distended from the first, hard, and board-like; peristalsis is not visible; the pain is great and increased on the least pressure; the pulse is small and wiry; the temperature may or may not be raised. (See *Peritonitis*, p. 549.) There will probably be a history of previous attacks of appendicitis or peri-typhlitis, or of gastric ulcer, or the patient is suffering from typhoid fever or has had uterine or ovarian troubles, etc.

Peritonitis from perforation in typhoid fever.—The diagnosis of this condition is described in works on Medicine. It is sometimes difficult, and cases presenting typical symptoms have been explored without any perforation being found. Leucocytosis, the white blood-cells being increased to 20,000 or more per 1 cb. mm., is reported to be a trustworthy sign. After perforation the peritoneal fluid is found to contain cocci and the typhoid and colon bacilli. When no

perforation was found on exploration, the bacteriological examination proved negative. Expectant medical treatment is uniformly fatal. Surgical treatment has resulted in recovery in about one case out of ten. Each case of recovery must be therefore regarded as a life saved. No harm has followed negative explorations. The operation must be performed as soon after the perforation, and as rapidly, as possible. To wait for recovery from collapse is to allow the peritonitis to spread beyond hope. A little general anæsthetic is given; this is much better than attempting the operation under cocain, for incising the parietal peritoneum is very painful, and the patient's abdominal wall is kept rigid. An incision is rapidly made into the peritoneal cavity (either an iliac incision or an incision through the outer border of the rectus). The fluid is sponged out, and if the perforation is easily reached it is invaginated and sutured. The gut must be treated most gently, lest it tear. If the perforation cannot be found, or there are several and the patient is weak, strips of iodoform gauze are quickly passed down to the perforation. If the perforation has been well closed, the abdominal cavity is simply sponged out, or if the fluid has widely extravasated swilled out, then sewn up. The external wound will be very slow in healing, and the sutures must be kept in as long as possible. If the wound is filled with gauze, a little of the strip is drawn out each day.

Chronic enteritis and colitis.—Perforation, or stricture and obstruction, has resulted from dysentery or other causes. To anticipate these accidents, after medical treatment has failed, cases have been treated by right colotomy and the lower gut continually irrigated. But the better treatment is to establish an anastomosis. The short circuiting gives an opportunity for the ulcerated bowel to heal.

Subacute and chronic peritonitis may be *tuberculous*, *gonorrhœal*, or *pneumococcal* in origin; or it may result from *cancer* (p. 875) or from *hydatids* (p. 166).

Tuberculous peritonitis is chiefly seen in tuberculous children. It may be diagnosed by the presence of other tuberculous lesions or by the history of the parents. The tubercle reaches the peritoneum from the intestine, possibly through the blood. In girls approaching puberty the primary disease may be situated in the uterine appendages. Two chief forms are met with: (*a*) *Tuberculous peritonitis with effusion.* The abdominal cavity is distended with a turbid fluid, whilst the peritoneal surface shows miliary tubercles. (*b*) *Tuberculous peritonitis with adhesions*, in which little fluid is found, but marked adhesions, matting together and tending to constrict coils of intestine, fusing the omentum into a mass, infiltrating both the parietal and visceral peritoneum with caseating tubercle and attended by enlargement of the retroperitoneal lymphatic gland.

When there is marked effusion and no adhesion, nor infiltration below the surface of the peritoneum, surgical treatment has been very successful. A short incision is made and the abdominal cavity irrigated until clear water is returned, when the wound is sutured. This operation may be expected to cure. When there is but little effusion, the intestines and omentum are matted together, and the peritoneal surface is infiltrated by caseous tubercle, very little good can generally be anticipated by operation. Indeed, harm may easily be done, for the intestines, being infiltrated, may tear like wet blotting-paper, and the result is a fæcal fistula without any compensating advantage, for it is impossible to wash out the abdominal cavity and start healing. When, however, a coil of intestines is kinked and matted, short circuiting by joining the gut above to the gut below may remove the danger of obstruction and give time for spontaneous healing.

Purulent peritonitis is set up by *pneumococci* following inflammation of the lungs. *Gonorrhœal peritonitis* may spread from the female pelvic organs, less commonly from those of the male. The abdomen must be washed out and drained.

APPENDICITIS AND PERITYPHLITIS.

There are three clinical conditions which should, if possible, be distinguished from one another: 1. Cæcal distension, retention in the cæcum or typhlitis stercoralis. 2. Perityphlitis or peritonitis around the cæcum and appendix. 3. Appendicitis or inflammation of the appendix and septic complications. These three have to be distinguished from typhoid fever.

1. **Cæcal distension. Retention in the cæcum. Typhlitis stercoralis.**—In this condition the cæcum is distended with fæcal material, solid, semi-solid, liquid, or gaseous, and this, with decomposition of the retained contents, and in consequence a certain amount of toxic absorption, may constitute the whole illness. In addition there may be some actual inflammation of the walls of the cæcum leading to thickening or even ulceration, or by means of the toxins to simple perityphlitis and adhesions around the cæcum and appendix. Cæcal distension is generally the result of chronic constipation, but it may be due to obstruction, as for instance from malignant disease in the colon, when the cæcum may be so distended and weakened by inflammation and ulceration that septic inflammation spreads from it to the peritoneum around.

Cæcal retention is generally seen in later life and in patients subject to constipation, especially women, whether the constipation has been definite in character or merely that the motions have been irregular and insufficient. The distension is the primary condition and exists, although perhaps unnoticed, before the onset of pain. The distended cæcum is recognised by its outline in a thin subject

and by palpation. It may contain hard scybala, which have often been mistaken for malignant disease, doughy fæces which yield to finger pressure, a mixture of fluid and gas which gives rise to gurgling under the fingers, or gas alone, in which case percussion yields a tympanitic note.

The pain is not very marked, and is general over the distended cæcum. Rarely there may be an acute attack of colic, that is, paroxysms of pain which double up the patient, rendering the abdominal wall so rigid that the distended cæcum cannot for the time being be felt. Vomiting may occur with this attack, also a slight rise of temperature. The diagnosis is rendered probable by the age of the patient, the previous history of constipation and the absence of the special signs of appendicitis; but it can only be rendered definite when complete relief follows aperient remedies, for example, a castor-oil enema, or calomel by the mouth. The distension disappears when the bowels act, there is no further vomiting or fever, and in a day or so all tenderness has disappeared from the ileo-cæcal fossa, and there remains no sign on deep palpation of an enlarged appendix. Although so quickly relieved care should be taken that a return of the distension is prevented. A repetition of the inflammation may lead to perityphlitis, and ultimately the appendix may become involved. But the disease is essentially one for medical treatment throughout. If in spite of treatment distension of the cæcum persists, some obstruction in the colon beyond, such as carcinoma in an obscure situation like the hepatic flexure, is indicated.

2. **Perityphlitis** is the term employed for a peritonitis localised to the region of the cæcum without denoting the seat of origin of the inflammation (Treves). American surgeons in particular relegate this name to the background as indefinite, speaking of the condition as a complication of appendicitis (*peritonitis appendicularis*). This it undoubtedly is in many cases, yet it certainly occurs without the appendix being diseased, and so is a class of case worthy of note in distinguishing between medical and surgical treatment. The perityphlitis may arise from the cæcum, probably through toxins as distinct from germs. The inflammation is generally fibrinous, and is therefore followed by adhesions; but it may be serous with effusion or resolve completely leaving no adhesions behind. There are other causes of perityphlitis apart from mischief in the cæcum or appendix, especially inflammation of the ovary and tubes in women, typhoid fever, enteritis, and perhaps also cold and injury.

The special *signs* of perityphlitis are those of local peritonitis with tenderness and rigidity of muscles persisting after the cæcum has been cleared by an aperient. Pain and disturbance of the temperature and pulse are little marked. The diagnosis cannot be completed until the acute symptoms have subsided, when a careful examination must be made, to distinguish it from a slight attack of appendicitis

and to determine whether the appendix has been secondarily involved and kinked by the adhesions.

Perityphlitis is therefore amenable to medical treatment, rest, aperients, and local application of belladonna and opium. But signs of a thickened appendix, or an enlarged and tender ovary or tube adherent to the appendix renders the case one for surgical treatment.

3. **Appendicitis** is a disease of the appendix itself, essentially due to septic decomposition of retained mucous and fæcal contents, which gives rise to septic inflammation extending beyond the walls of the appendix. The course of the disease from day to day cannot be anticipated. Medical treatment has no influence over it whatsoever. The only treatment is surgical, the only cure the removal of the appendix at the earliest fitting opportunity.

The disease is at the present time of very common occurrence; apparently it was formerly confused with typhlitis and perityphlitis. There is no positive proof that it is becoming really more frequent of late years. On the other hand, the great attention now paid to it by surgeons threatens to obscure the frequent occurrence of slight cases of typhlitis and perityphlitis occurring in general practice.

No age is exempt. It has been seen in infants and in old men over seventy; but it is particularly a disease of adolescence, half the cases, and these the most dangerous ones, occurring under twenty. It is then much more common in males.

Causation.—Generally speaking, it may be said to arise from a retention in the appendix of fæcal and mucous contents, the emptying of the appendix by peristalsis being prevented. The conditions that may lead to retention in the appendix are considered under the following heads:—

A. *Congenital defects.*—As a remnant or vestige of the larger cæcum of lower animals the appendix is subject, like other remnants, to anatomical variations in structure and position. Thus its lumen may be narrowed at its juncture with the cæcum, or nearer the tip, or the shortness of its mesentery may cause the appendix to become kinked or curled or bent, or it may be prolapsed into a retro-cæcal fossa, or into an external hernia where it can be easily compressed, or it may be excessively long, and may then hang over the brim of the pelvis.

B. *Foreign bodies.*—It is now recognised that the concretions met with are mostly fæcal and have originated in the appendix itself. Occasionally a foreign body, a fruit-stone, pin, a worm (*Oxyuris vermicularis*, or *Ascaris lumbricoides*, or *Tricocephalis dispar*) is met with.

C. *Constrictions* from perityphlitic adhesions, the result of cæcal irritation caused by improperly masticated or indigestible food, constipation, cold, or injury.

D. *Special diseases*, such as tubercle commencing in the peritoneum, pelvic organs, or in the appendix itself, actinimycosis

and malignant disease arising in the cæcum or appendix, and typhoid fever.

Pathology—1. *Mucus and organisms.*—The normal mucus of the appendix contains the colon bacillus, less often staphylococci, streptococci, and perhaps other organisms living as saprophytes, and apparently in a latent state of activity. If the mucus is retained these organisms become active, virulent, and pathogenetic. Whilst at first only the toxins derived from these organisms may pass through the muscular and serous wall and set up merely a simple inflammation, at any time the active germs themselves may reach the serous surface and attack the peritoneum, or the subperitoneal loose connective tissue, or they may enter the artery and vein of the appendix and cause septic thrombosis, or invade the lymphatics. The septic infection is a mixed one, but we may recognise staphylococci as chiefly causing suppuration and abscess, streptococci as giving rise to spreading fibrinous œdema, and the colon bacillus as producing foul gas and sloughing, so that the extensions of the inflammation from the appendix may show a mixture of all these characters, or one of them more prominently than the others.

2. *Concretions.*—The appendix may contain true fæcal concretions or coprolites. Enteroliths proper, where the fæcal constituents and inspissated mucus are mixed with calcareous material derived from the inflamed wall, as in like manner are tonsillar concretions and rhinoliths, are more rare, whilst foreign bodies, such as fruit-stones, vegetable materials, a pin, etc., are still rarer. The concretion may be small, rounded like a shot, and multiple, or single, occupying the lumen which is stretched over it and is then oval, or spindle shaped, like a date-stone, and may be as large as the top of the finger. It has on its surface the same organisms as has the mucous contents, and carries them with it should it cause ulceration of the appendix wall and be discharged into the peritoneal cavity. Occasionally after escaping from the appendix a concretion may become encysted and calcareous.

3. The *changes* met with *in the appendix wall* are: (*a*) Slight superficial ulceration of the mucous membrane followed by annular constrictions, with dilatation of the distal part by the mucous contents so to form almost a cyst. (*b*) More or less uniform thickening of the submucous and muscular coat by fibrous tissue. (*c*) Septic inflammation of the wall producing swelling and œdema, and sometimes the formation of small abscesses. (*d*) Septic ulceration with gangrenous edges, which may penetrate and form a communication between the interior and the outer surface. (*e*) Sloughing and gangrene due to obstruction in the single artery and vein of the meso-appendix by kinking or by septic thrombosis. The relatively fewer number of females attacked has been attributed to the appendix in them having an additional blood supply from the ovarian artery. A considerable portion or the

whole of the appendix, and especially that part in which a concretion is fixed, may thus be affected. The dead wall no longer resists the passage of the septic germs, which now freely pass through it. There is also leakage of fæcal mucus at the line of demarcation between the living and gangrenous part, which finally forms a slough.

A spontaneous cure without septic extension has been stated to occur by obliteration of the lumen of the appendix, the mucous membrane being first destroyed by ulceration or sloughing, the muscular wall contracting, and the appendix at last being reduced to a fibrous cord. If this occurs without septic inflammation reaching the exterior, it is at any rate very rare, and in no way to be counted on for curing the patient. Moreover, if obliterated, the appendix may form a band binding down the cæcum or some other organ, and thus become a source of future trouble.

4. *Changes around the appendix.* — *Simple* inflammation may lead to the formation of fibrous adhesions, which unite the appendix with the parietes, cæcum, omentum, small intestines, rectum, bladder, or female pelvic organs. *Septic* inflammation, reaching the peritoneal surface, may rapidly spread over the peritoneum, causing a generalised peritonitis with a little exudation of an oily character (*dry or greasy peritonitis*), or there may be extensive exudation with redness or œdema of the peritoneum (*sero-purulent peritonitis*). Or a limited peritonitis is produced, adhesions gluing beforehand coils of the bowel together and shutting off suppuration from the general peritoneal cavity, and thus producing a unilocular or multilocular abscess, which may contain foul pus, fæcal concretions, or the gangrenous or sloughed appendix; or the appendix may be embedded in the wall of the cavity. Such an abscess is intra-peritoneal as regards its origin, but from a surgical point of view is extra-peritoneal, since it can be incised without opening the general peritoneal cavity. When the appendix lies in the retrocæcal fossa the abscess becomes shut off from the rest of the peritoneal cavity by the adhesions about the mouth of the fossa. So also a localised intra-peritoneal abscess may arise in the pelvis or near the kidney, or under the liver or diaphragm. If the suppuration then becomes extra-peritoneal it does so by perforating the parietal peritoneum, most commonly through the abdominal wall in front, more rarely in the loin. It may then extend in the muscular planes of the abdominal wall, even into the thigh. Lymphatic absorption may lead to liver abscess, empyema, or general pyæmic infection.

Clinical signs.—An attack of appendicitis is characterised by:

(*a*) *Pain*, especially felt over the point of junction between the appendix and cæcum. The patient puts his finger on a spot (*McBurney's point*) midway between the anterior superior spine of the ilium and the umbilicus, at the outer border of the rectus. The pain in most instances comes on in paroxysms with intervals of subsidence; it may from the first be at McBurney's point, it may be

referred to the umbilicus, or it may be epigastric or general, but soon tends to be localised in the right iliac fossa. Speaking generally, the pain gets less as the inflammation progresses.

(*b*) *Tenderness.* This in an acute case is most marked, so that the patient cannot bear the slightest pressure in the appendix region. In subacute and chronic cases there is deep tenderness either at McBurney's point, or, at least, more marked there than in other parts.

(*c*) *Rigidity,* especially of the right rectus muscle, which resists pressure, guarding, as it were, the inflamed appendix. But the rigidity may be widespread over the ileo-cæcal region.

(*d*) *Swelling.* A palpable swelling, formed by the inflamed appendix and by the exudation around, is felt in the right iliac fossa, and may extend as high as the umbilicus, as far forwards as the middle line and backwards into the loin. It is possible in thin patients to feel a normal appendix, which can be rolled beneath the fingers like a thick cord on the psoas muscle without exciting pain. When inflamed with exudation around, the appendix feels hard, swollen, unyielding, or partly moveable, but this swelling may be masked by the rigidity of the abdominal wall.

Other signs of appendicitis are variable. *Vomiting* in the great majority of cases may be absent, or in an acute attack, it may occur only once, but reappear and then be continuous when general peritonitis has supervened. Both the *temperature* and *pulse* are subject to much variation, which will be again referred to. There is generally *loss of appetite, furred tongue,* and *constipation,* perhaps *retention of urine;* or there may be *diarrhœa* and frequent *micturition.* Appendicitis may easily be mistaken for typhoid fever; but in typhoid fever there are special peculiarities: frontal headache, often severe epistaxis, insomnia, bronchial catarrh, and the presence of rose-coloured spots; especially also the changes in the blood as marked by Widal's reaction, and the presence of typhoid organisms in the urine. The pain and tenderness in the ileo-cæcal fossa are diffuse, and not severe nor localised at a special spot. The typical characters of typhoid are diarrhœa with peculiar (pea-soup) stools, whereas in appendicitis there is constipation; but the reverse may occur—constipation in typhoid fever, or even diarrhœa in appendicitis. Appendicitis attended by suppuration is accompanied by leucocytosis. Leucocytosis may also be met with in typhoid fever should perforation occur.

Clinical varieties.—(*a*) **Acute perforating appendicitis.**—The patient is suddenly attacked with acute pain and collapse, such as occurs in other cases of perforation and strangulation. There is also pain, tenderness and rigidity localised at McBurney's point, which does not last long, but merges into general septic peritonitis. The temperature may be subnormal. During the stage of collapse the pulse-rate may be at first normal, but it soon rises to 110 or more, and becomes small and hard; later the temperature also rises.

After the acute onset a quiescent period may follow, especially when the patient is given opium or morphia. Then the abdomen, which at first may be retracted, begins to be distended by tympanites, so that little can be distinguished by palpating the ileo-cæcal fossa. In commencing general and pelvic peritonitis a finger passed into the rectum will detect marked tenderness in the upper part. The fur on the tongue becomes drier, browner, and more shrunken; there is obstinate constipation and frequent vomiting, at any rate when anything is given by the mouth. Perforation of an appendix may be suspected in young people, for example, school-boys, suddenly attacked by acute abdominal symptoms or collapse. Intussusception, internal strangulation, and a strangulation by Meckel's diverticulum, may give rise to similar signs, but prompt surgical methods are here also required Acute renal colic in young people is usually attended by pain radiating at once to the groin; the testicle is retracted, the urine altered, micturition disturbed. It is some time after the onset, and only when the appendix is fixed near or in the abdominal ring, or prolapsed into the pelvis with commencing suppuration, that we meet with similar signs in appendicitis. In young patients the perforation is more often primary, and the peritonitis generally dry or oily; in older patients the perforation is secondary to ulceration and abscess, and is often limited and purulent, the symptoms of pain, tenderness and rigidity undergoing a temporary remission when the pus is extravasated.

In such a patient other causes of perforation, gastric, duodenal, biliary or tubal, or a volvulus, etc., may at times be confused with appendicitis, but all require laparotomy, as do the perforations which occur in the course of typhoid fever.

(*b*) **Suppurative appendicitis.**—In an *acute* or *sthenic* case the onset of suppuration is sudden, and is rapidly followed by a well-marked swelling in the ileo-cæcal fossa. Suppuration is indicated by increasing tenderness—it may be œdema—over the most prominent parts of the swelling, the percussion note becoming less resonant, then dull. Whilst the general condition of the patient gets worse and the pulse quickens, the temperature may fall, but not to normal, with the onset of the suppuration, and the patient often experiences some relief of pain and tension, or rigors may usher in the suppuration; but these symptoms must not be depended upon. The abscess when posterior may by irritating the psoas muscle cause flexion of the hip, with pain extending down the cord to the testicle, but there should be no difficulty in distinguishing suppurative appendicitis from hip-joint disease and inflamed glands in the groin, in both of which there is a swelling below Poupart's ligament.

In a *subacute* or *asthenic* inflammation the onset of suppuration is slower. The patient, who has generally had more than one attack of typical appendicitis, may be suffering from septic anæmia, with tenderness and œdema about McBurney's point. He has a

brown, dry tongue, foul breath and motions, a slightly jaundiced, earthy aspect, and wastes rapidly. The temperature tends to be hectic, with night sweats, the pulse to rise to 110 or more. The closest watch is required to detect increasing fulness in the groin, loin, pelvis, etc.

The onset of suppuration, whether acute or insidious, is marked by leucocytosis, the white cells numbering 20,000 per 1 cb. mm. or more. Numerous cases have now shown this to be generally a very trustworthy sign, but the authors have met with cases where, even with an increase of white cells up to 25,000, the inflammation has subsided without suppuration.

(*c*) **Relapsing or recurring appendicitis.**—This term has been applied to cases of appendicitis in which attacks of varying degrees of severity succeed one another without warning, and in spite of dieting and treatment; no idea can be formed from previous attacks what may happen in the next. Between the attacks, a careful examination with one hand on the inguinal region and another in the loin, or by a finger in the rectum or vagina, will detect a more or less thickened and tender appendix. These cases, therefore, should be regarded as chronic appendicitis, with acute or subacute exacerbations, rather than as recurrent attacks.

(*d*) **Chronic latent appendicitis.**—Insidious cases of ill-health, anæmia, loss of flesh, chronic dyspepsia, irregularities of the bowels, really due to chronic inflammation of the appendix, may give rise to all sorts of conjectures as to their origin, and may be attributed to gastritis or pulmonary tuberculosis, until a careful examination of the cæcal region discloses an enlarged and tender appendix. There may be no history of any attack, and the disease may go on to suppuration and septic absorption before a diagnosis has been made.

Complications of appendicitis.—These are most numerous. Thus, there may be (1) peritoneal extension: to the pelvis, right loin, sub-hepatic and supra-hepatic region, the splenic region, the left ileo-cæcal fossa, left loin, a hernial sac, or to the midst of coils of intestines, giving rise to abscesses in these various situations. (2) Subperitoneal extension: directly through the abdominal wall, obliquely along muscular planes, across the abdomen to the opposite side, downwards by the side of the rectum to the ischio-rectal fossa, along the sheath of the iliac vessels to the thigh, or upwards behind the colon, along the vena cava, or through the diaphragm to the thorax. (3) Visceral extension: by rupture into the cæcum, colon, rectum, or bladder. (4) Absorption by veins and lymphatics: to the liver, causing pylephlebitis and empyema of the gall-bladder, lymphatic œdema of the lower extremity, septicæmia and pyæmia—especially pyæmic inflammation of the parotid. (5) Pleural or pericardial empyema, septic pneumonia and pulmonary abscess. (6) Local complications: fistula, purulent or fæcal; hernia from a

weakened abdominal wall; sloughing of the parietes with prolapse of the intestines; secondary hæmorrhage from the artery of the appendix, circumflex iliac artery, or iliac vein.

Indications for treatment.—1. Great differences of opinion are expressed as regards the treatment of appendicitis. General practitioners and physicians who see the cases described above under cæcal retention and perityphlitis recovering under medical treatment, are led to treat appendicitis expectantly. Surgeons, on the other hand, being more frequently called in to operate as a last resource in cases of true appendicitis, and when it is then too late to save the patient, are the more inclined to urge operation at the earliest possible period—that is, within the first twenty-four hours of the attack; and the more so, seeing the difficulty there is of forming a correct prognosis as to the course of the case on the whole, and as to its progress from day to day. As Morris, of New York, puts it, the affected appendix may be compared to a cap which sometimes snaps, sometimes flashes, and sometimes causes an explosion, and none of us can be quite sure in advance what is going to happen. The expectant treatment, therefore, is held by many to be simply leaving the patient to chance. On this point Dr. Murphy, of Chicago, who may be taken as voicing the general surgical opinion in America, says:—"As all cases should be operated upon sooner or later, the time to perform the operation is that which entails the least danger to the patient, *i.e.*, within twenty-four hours of the first attack. The medical profession" (he goes on to say) "will finally come to the twenty-four hour standard, as I have done for many years. All other times are poor substitutes. The real life-saving operation is the operation within the first twenty-four hours of the first attack."

No doubt there is much to be said in favour of operation during the first twenty-four hours, seeing that no one can be sure whether perforation or gangrene may not occur, or whether suppuration may not take place around the organ. On the other hand, when the operation is done at this early period, whilst the appendix is acutely inflamed and full of teeming, active bacteria, there is some risk of flooding the peritoneum with septic material, and thus producing the condition—namely, diffuse peritonitis—which the operation is undertaken to avoid. An operation at this period, moreover, as a rule, necessitates a tube or gauze drain, thus weakening the abdominal wall. Many surgeons, therefore, prefer to watch the case for a few hours, and, provided it gives indications of running a favourable course, postpone the removal of the appendix till the acute symptoms have completely subsided, when appendicectomy may be undertaken with practically no risk, and the wound in the parietes can be so firmly closed that there is no subsequent fear of a hernia following. If, therefore, within twenty-four to thirty-six hours there is a gradual fall of temperature, a steady decrease in pulse-rate, a

subsidence of the pain and its localisation to the right iliac fossa, absence of rigidity, no tenderness in the rectum, no vomiting, and a general improvement in the patient's facial expression and condition, the appendicectomy may be safely postponed till the most favourable period for the operation, namely, the quiet interval. No one of these signs, however, can be depended upon alone as showing that the inflammation is tending to subside. Thus a fall of temperature may depend upon increased septic absorption, which has also a tendency to deaden the pain, and the pulse may remain low. Moreover, the symptoms may be masked by an injudicious administration of opium or morphia; and they may also be temporarily relieved by an action of the bowels. If the surgeon, therefore, is in doubt, the safest course is an early operation.

2. In cases where the signs of acute perforating and gangrenous appendicitis are undoubtedly present, all surgeons are agreed that immediate recourse to operation gives the patient the only chance.

3. Suppuration being diagnosed or reasonably suspected of setting in, the surgeon should operate at once, taking great care not to invade the general peritoneal cavity. Some surgeons designedly delay until an abscess fluctuates and tends to point, in order that adhesions may form and shut off the peritoneal cavity. But the delay is attended by the danger of the abscess bursting into the general peritoneal cavity, or of the inflammation extending and giving rise to one or more of the conditions mentioned under *Complications of Appendicitis.*

4. Recurrent appendicitis. Supposing a thickened and tender appendix to be found after the first attack has subsided, immediate removal should be advised. An attack will certainly recur; there are no means of preventing it. It may come on without warning, and it is impossible to say what may be its character. To designedly advise waiting for a second attack is to put the patient to unnecessary risk.

Operation for appendicitis.—(1) *Appendicectomy or removal of the appendix.*—The iliac incision commences above and internal to the anterior superior iliac spine and ends just external to the middle of Poupart's ligament. The aponeurosis of the external oblique is divided in the course of its fibres. Then with two pairs of anatomy forceps, aided by fingers or retractors, the internal oblique and transversalis fibres are separated and the transversalis aponeurosis cut through. When there is no evidences of suppuration, a small opening is made in the peritoneum, and the appendix sought for. If free, it can be drawn through quite a small opening. If it cannot be found at first, the cæcum, recognised by its longitudinal bands, is drawn a little outwards, and the two longitudinal bands traced to their convergence at the root of the appendix.

The appendix being found free, a ligature is passed by means of

an aneurysm needle through the meso-appendix at the angle of junction of the appendix with the cæcum. The needle is then withdrawn and the ligature firmly tied, thus securing the single artery in the free edge of the meso-appendix. The appendix can now be severed with scissors from the meso-appendix without any bleeding. If adhesions are met with, these are clamped, divided and tied, since should a vessel not be secured troublesome recurrent hæmorrhage will follow. When the appendix is buried in adhesions, it is shelled out, commencing from its root and working towards the apex between the peritoneal and muscular coat. Having freed the appendix, a circular incision about half an inch from the cæcum is made through its peritoneal coat, which is then turned back, like a cuff, over the proximal end at its junction with the cæcum, from the thick whitish musculo-mucous coat. Round this is tied a ligature, and the appendix is cut away beyond and the stump

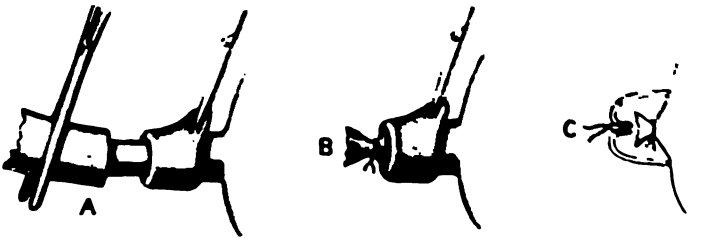


FIG. 431.—Excision of the appendix. A. Serous coat turned back as a cuff and pressure forceps compressing appendix to prevent escape of contents. B. Mucous and muscular coats tied. C. Serous coat united by Lembert's sutures over ligatured stump of muscular and mucous coats.

touched with pure carbolic acid (Fig. 431). Instead the appendix may be simply cut off, or burnt off with a cautery or crushed. Now a bag suture is inserted into the peritoneal flap and tied over the stump, which may be further invaginated into the cæcum by a second bag suture applied over the first. Or three or four Lembert's sutures may be employed to draw the peritoneal cuff over the stump (Fig. 431). The peritoneum, the muscles, and the aponeurosis of the external oblique are successively united with buried sutures, the skin wound closed by fishing-gut sutures, a pad and strapped dressing are applied, and the patient is put in bed with his knees over a pillow.

(2) *Operation for opening an appendix abscess.*— Suppuration being suspected, the incision, if the swelling is in the more usual situation, namely, that shown in Fig. 432, 2, should be made much lower than that for the removal of the appendix so as to avoid opening the general peritoneal cavity. On reaching the transversalis fascia, œdema is sought for, or a special induration is felt with the finger, or the parts are gently scratched through with

anatomy forceps or with a director until pus is reached. If the general peritoneal cavity is opened it should be carefully closed with sutures before searching for the pus, which should then be looked for with forceps or director below the peritoneal reflection, and if not found there may then be sought in one or other of the situations shown in Fig. 432, the peritoneal cavity being carefully shut off with gauze or sponges. Pus being reached, the surgeon should be content, in Walsham's opinion, to simply plug the wound

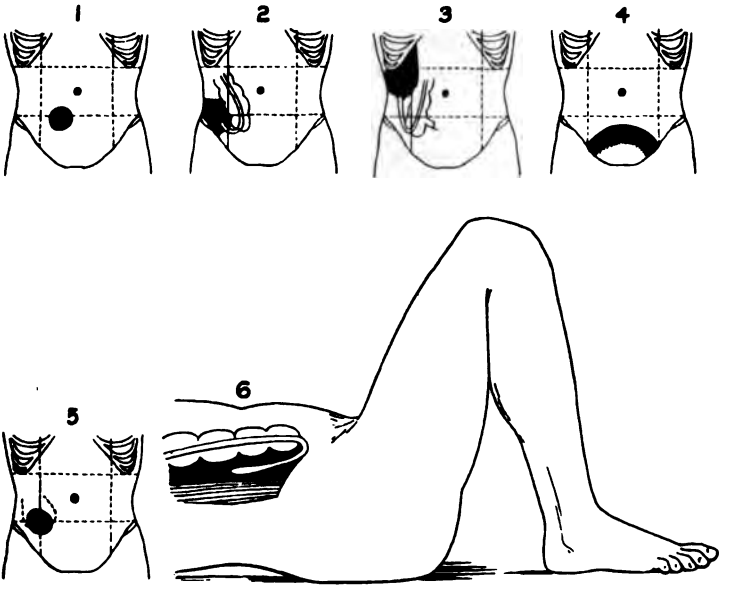


FIG. 432.—Suppurative appendicitis. Positions of the abscess, after Morrison. 1. Internal to the cæcum, between it and the omentum and intestines. 2. External to the cæcum, between it and the crest of the ilium below the kidney. 3. Under the liver, in front of the kidney. 4. In the pelvis, covered by intestines and omentum. 5. Behind the cæcum. 6. Extending up behind the ascending colon, to be reached by extending the iliac incision backwards into the lumbar region.

lightly with gauze or insert a drain tube. Searching for the appendix, washing out the cavity of the abscess, and exploring with the finger he holds are highly to be condemned. He has seen the most calamitous results follow such procedures, namely, the breaking down of adhesion, flooding the general peritoneal cavity with septic fluid, and rapidly fatal diffuse peritonitis, whereas when the abscess has been simply opened and drained no bad result of any kind has followed. The appendix is either discharged with the pus as a slough or undergoes obliteration or molecular disintegration, and gives rise to no further trouble; only in very exceptional instances has it led to any subsequent mischief. The patient should have the bowels open

after twenty-four hours, and then at each daily dressing three or four inches of the gauze strip is pulled out, twisting the strip up should it stick, until in a week or so all the gauze is removed, when no more is required. Should, however, a sinus remain and refuse to heal, a most exceptional occurrence, it may be laid open when the acute symptoms have entirely subsided and the appendix removed. If a fæcal fistula forms no treatment beyond gentle syringing out is required. Such a fistula in this situation nearly always heals spontaneously.

Spencer, on the other hand, believes that when pus is reached the abscess cavity should always be gently examined with the finger in search of pockets and tracks of extending suppuration. If these are found, communications are made so as to form a single cavity, which is then wiped out with an antiseptic, dried and filled with iodoform gauze, taking care especially to shut off with the gauze any communication which has been made with the general peritoneal cavity. Sometimes a counter-opening may be made with advantage, and a tube passed out by the loin (Fig. 432, 6). In a favourable case, after ten days or so, when the septic inflammation has subsided, the appendix can be successfully dissected out, and the patient thus cured in a relatively short time. In a more severe case, as soon as his strength will allow, the patient should go to the seaside or country for a while, whether the wound has healed or not, and then return for removal of the appendix if in the meantime it has not come away.

(3) *Operation for purulent peritonitis.*—The incision should be prolonged backwards towards the loin until a sufficiently wide opening is made, the muscles for this purpose being freely divided. The gangrenous or perforated appendix is removed. In this way as much of the infected peritoneal cavity is sponged or wiped out as can be done without letting out the intestines; the cavity plugged with gauze and left wide open, no stitches whatever being inserted. If the cavity is irrigated freely and the intestines are allowed to come out, the patient nearly always dies of shock or later of general peritonitis. The lateral incision, in that it allows the intestines to be retained, has been more successful in its application than the median incision. The patient's head and shoulders should be subsequently kept raised to prevent septic fluid travelling upwards by gravity.

HERNIA.

The term Hernia, though often used in conjunction with other terms to signify the protrusion of any viscus from its containing cavity, as "*Hernia cerebri*," or "*Hernia testis*," when employed alone is applied only to such a protrusion from the abdomen or pelvis, and is equivalent in this sense to the term Rupture, the name by which the affection is popularly known.

Description of hernia in general.—A hernia may occur at almost any situation, but is most common at the inguinal and femoral rings, spots at which the abdominal parietes are naturally weaker than elsewhere. It generally consists of intestine, or of omentum, or of both; but almost every one of the abdominal or pelvic viscera have at times formed the protrusion.

The causes of hernia are predisposing and exciting. *The predisposing* may be divided into: 1. Hereditary and congenital malformations, such as an elongated condition of the mesentery, a patency of the funicular portion of the tunica vaginalis or canal of Nuck, or a dragging down of a process of peritoneum by fibres of the gubernaculum testis, distinct from that for the descent of the testis, and congenital defects of the abdominal parietes. 2. Acquired elongation or downward displacement of the attachment of the mesentery. 3. A relaxed condition of the abdominal muscles, such as is induced by pregnancy and by rapid emaciation in persons previously stout, and in children by irregular feeding and weak muscular development. 4. The excessive formation of fat in the omentum or mesentery. 5. Any injury or operation that has weakened the abdominal walls. 6. Occupations involving severe muscular exertion. *The exciting causes* are such as produce a diminution in the size of the abdominal cavity by the contraction of the muscles forming its walls and the consequent compression of the contained viscera. They may be divided into those that act suddenly, and those that act slowly. Amongst the former may be mentioned sudden and violent exertions, straining at stool, lifting heavy weights, etc. But a true rupture of muscle or fibrous tissue is rare. Amongst the latter, continual straining, as from stricture of the urethra, enlarged prostate, phimosis, or a narrow meatus, constant coughing occasioned by chronic bronchitis and emphysema, etc.

Hernia in relation to age and sex.—Infants are born with umbilical hernia, owing to delay in closure of the ring at the umbilicus. In children hernia is nearly always inguinal, is ten times more common in boys than in girls, and is seen more often on the right than on the left side, presumably owing to the later closure of the tunica vaginalis. Too much stress must not be laid to phimosis as a cause of the greater frequency in boys, for Jewish children frequently suffer. Inguinal hernia is more common in men than in women, as the former are more exposed to the action of the exciting causes mentioned above. Nearly all the cases of femoral hernia requiring operation occur in women; femoral hernia occurring in men does not attain such dimensions, and is easily controlled by a truss. Umbilical hernia is especially prevalent in women who have borne children and have then got fat.

Anatomy of hernia.—As the viscus is protruded through the abdominal or pelvic parietes, whether at one of the so-called rings or elsewhere, it generally forces that portion of the parietal

peritoneum, which lies over the aperture, before it in the form of a pouch. When it escapes at the internal inguinal ring, however, instead of thus protruding the peritoneum in front of it, it may pass into the tubular prolongation of peritoneum which naturally descends in front of the testicle in the fœtus, and which from some cause has remained unobliterated. The pouch of peritoneum in which the protruded viscus is thus enclosed is called the sac. In the former case it is spoken of as an *acquired*, in the latter as a *congenital* sac. In some forms of cæcal hernia the sac may be incomplete, *i.e.*, the viscus may be covered by peritoneum only in front, and in contact with the tissues behind; and in diaphragmatic hernia, and in hernia following a wound of the abdominal walls where there is no parietal peritoneum covering the aperture, there will be no sac. The protruded viscus enclosed in its peritoneal sac forms a swelling surrounded by the tissues of the part into which it has escaped. The tissues superficial to it, *i.e.*, between the sac and the skin, form what are called its coverings. We have to consider, therefore, 1, the sac, 2, its contents, and 3, its coverings.

1. The *sac* is said to consist of a body, neck, and mouth, terms which sufficiently explain themselves. It is at first thin and membranous, resembling the peritoneum; but in old herniæ may become thickened and indurated, or else, as for example in umbilical hernia, attenuated, or in places absorbed. It is usually globular or pyriform, but may take almost any shape. Thus it may be fusiform, hour-glass-like, bilocular, or divided by adhesions into two parts, the lower part, perhaps, containing fluid and forming what is known as a *hydrocele of the sac*. The neck is at first slightly puckered, but as the result of inflammatory consolidation becomes in old herniæ smooth, thickened, and often indurated. The mouth may be wide and expanded, or, in the case of congenital herniæ, in which the neck is frequently elongated, narrow and contracted. The sac may be tuberculous when the peritoneum is similarly affected or may alone be so diseased.

2. The *contents of the sac* may be intestine alone (*enterocele*); or omentum alone (*epiplocele*); or both, the omentum then generally descending in front of the intestine (*entero-epiplocele*), or more rarely the intestine in front of the omentum (*epiplo-enterocele*). In exceptional instances the bladder, an ovary and tube, more rarely only a tube or a uterine horn—or the uterine body and even a pregnant uterus, and other of the abdominal or pelvic viscera, have been met with in the sac. The bladder forms a sacculus covered with peritoneum, beneath which is fat and muscular fibres, or it forms a lump in the wall of the sac uncovered by peritoneum. The sacculus may be empty or contain urine or a stone. It should be looked for particularly in a direct hernia. The small intestine, and especially a portion of the lower three feet of the ileum, most frequently descends. When the large intestine descends it is generally the

cæcum; but any portion of the small or large may do so. There may be but a small knuckle of intestine in the sac, or a part only of its calibre, or a Meckel's diverticulum or an appendix; but when once a portion of intestine has escaped there is generally a tendency for more to follow, and in old herniæ to the extent of several inches or even feet. The protruded intestine and mesentery in long-standing cases becomes hyper-vascular and thickened, and the omentum hypertrophied and matted together. A small quantity of serous fluid is also generally found in the sac, and in rare instances loose or attached fibrinous bodies somewhat similar to those met with in bursæ. Where the neck of the sac has become obliterated by the long wearing of a truss, the sac has been found filled entirely with serous fluid, thus forming a cyst or hydrocele of a hernial sac.

3. The *coverings of the sac* necessarily vary according to the situation of the hernia. They will be enumerated under each special form, and little more need be said about them here further than that they often become thickened, blended together, thinned, or absorbed, so that in actual practice they can seldom be demonstrated.

Fig. 433.—Spica bandage for the groin. (Bryant's Surgery.)

The conditions of a hernia.—A hernia may be: (1) reducible; (2) irreducible; (3) strangulated; (4) incarcerated, or (5) inflamed.

1. **A reducible hernia** is one that can be returned into the abdominal cavity; *i.e.*, it either goes back when the patient lies down; or it can be made to do so by the patient himself, or by the surgeon making pressure upon it in a suitable direction. The sac, except perhaps in quite recent cases, cannot be put back into the abdomen in consequence of its adhesions to the surrounding tissues, but remains empty *in situ*.

Symptoms.—At first there may be a mere fulness or protrusion, commonly at one of the abdominal rings; the protrusion becomes more prominent when the patient stands up, strains, or coughs, but it completely disappears on his lying down. If neglected it gradually increases in size, forming a prominent non-translucent swelling, in which a distinct impulse is felt on coughing. If the hernia contains intestine (*enterocele*), it will be tense and elastic, and resonant on percussion; whilst a peculiar gurgling is heard from the displacement of gas and fluid on returning it into the abdomen. If on the contrary it contains omentum (*epiplocele*), it will be dull to percussion, doughy and inelastic, or hard and resisting, and lobulated, whilst the characteristic gurgling is not heard on returning it to the abdomen

The *diagnosis* will be given under the head of *Special Herniæ*, as

it is from other diseases of each special region that a diagnosis has to be made.

The *treatment* may be palliative or radical. The *palliative* treatment consists in reducing the hernia and applying some form of truss, a pad and spica bandage being put on (Fig. 433), till a truss can be procured. The form of truss will vary according to the position, size, etc., of the hernia. Fig. 434 is an inguinal truss of the ordinary shape, and may be distinguished from a femoral (Fig. 435), by the pad of the latter being placed more vertically. Fig. 437 is

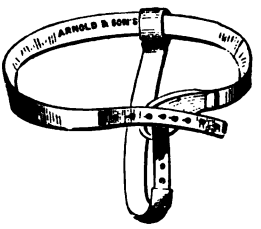


FIG. 434.—Inguinal truss.

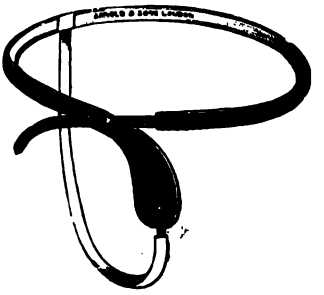


FIG. 435.—Femoral truss.

an umbilical truss. In measuring for a truss the following notes should be taken and sent to the maker:—1. The dimensions round the pelvis, midway between the crest of the ilium and the great trochanter. 2. The kind of hernia. 3. The side on which it is

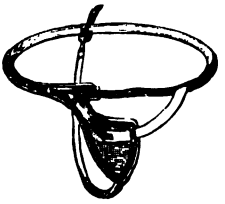


FIG. 436.—Bag truss for irreducible hernia.

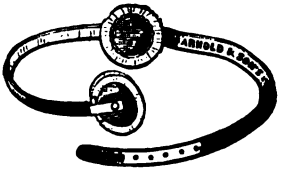


FIG. 437.—Umbilical truss.

situated. 4. The size of the ring. 5. The age and sex of the patient. 6. The strength of the spring required. The truss should be worn constantly, and never on any excuse be left off in the daytime. A lighter truss may be provided for the night, and one covered with india-rubber or made of vulcanite for the bath.

For children a light spring truss covered with rubber is best, but for infants the skein-wool truss, if properly applied, kept frequently changed and clean, is most efficient. Circumcision must at the same time be performed, if there is any phimosis.

The *radical* treatment consists in reducing the hernia, excising

the sac and closing the ring and canal. The scope of operative treatment for hernia is now very wide. It is indicated for:

A. *All cases of irreducible hernia*, except in bedridden and aged patients in whom the ring is very wide and the hernia not a cause of trouble. Even in them, as well as in patients with bronchitis and emphysema, the risk of the radical operation should be undertaken when there is any likelihood of strangulation supervening, for should this occur operation would most likely be fatal. The same applies to patients with diabetes, kidney or heart disease, etc. The operation becomes impossible when the hernia is of huge size and the abdomen contracted unless it consists mainly of omentum.

B. All cases where the *truss does not satisfactorily control* the rupture at all times, for example, in a child whilst crying, in a man whilst at work, in a woman who has become pregnant—for strangulation may in them suddenly occur.

C. In young children, who have worn a truss for a year without the hernia disappearing.

D. In all children over five, who still show a hernia; and in all healthy people, unless a light truss is so worn that the hernia is always kept up.

2. **An irreducible hernia** is one that cannot be returned into the abdomen.

The *causes* of the irreducibility, which are many, may be conveniently classified according as the impediment to the return of the contents of the sac exists—1. *Outside the sac*, from inflammatory thickening and contraction of the tissues forming the ring or other aperture through which the hernia has escaped. 2. *In the sac walls*, from inflammatory thickening and contraction, and from elongation of the neck of the sac. 3. *Inside the sac*, from (*a*), the great bulk of the intestine or omentum due to increased growth subsequent to their descent; (*b*), constriction of the omentum at the situation of the ring and expansion of the lower parts; (*c*), adhesion of the intestine or omentum to the sac, or to one another; (*d*), bands of adhesions stretching across the sac and so confining a loop of intestine or knuckle of omentum; (*e*), a collection of fluid in the sac; (*f*), a portion of intestine (as the cæcum) having descended uncovered with peritoneum on one aspect, the uncovered portion forming adhesions with the tissues around it where the sac is absent.

The *symptoms* are similar to those of the reducible form, save that the hernia cannot be completely reduced. Thus, there is impulse on coughing, non-translucency, and, when it contains intestine, gurgling on handling, and resonance on percussion. It is, moreover, often attended with dragging or colicky pains and dyspeptic symptoms or cough. When its contents are both intestine and omentum, the intestine can sometimes be returned. A consideration of the above signs should serve to distinguish it from

a hydrocele extending high up the cord with which it is perhaps most likely to be confounded. An irreducible hernia often attains a large size, and is not only on this account a constant source of annoyance to the patient, but is also one of danger, as there is always a risk of its becoming obstructed, strangulated, or inflamed, or ruptured by accidental blows, etc. The *treatment* may be directed to one of two ends:—1, to protect the hernia from injury and prevent it from getting bigger by the descent of more intestine or omentum, a procedure that should be reserved for old and feeble patients or cases otherwise unsuitable for operation; and 2, if possible, to render it reducible, or better, if the patient's general state of health is favourable, to cure it, by one of the radical operations already described. For the first purpose the patient should wear a bag truss (Fig. 436), or the lace-up truss. Trusses are often difficult to adjust. Under such circumstances a cast of the parts should be taken in plaster-of-Paris, and to this any instrument-maker can then accurately mould the truss. When the patient will submit, an attempt may be made to convert the hernia into a reducible one; and if persevered in will frequently, especially in recent herniæ, be successful. The patient should maintain the horizontal position, the diet should be restricted, saline purgatives given, and ice occasionally applied to the part, or continuous pressure may be kept on the hernia by means of the hinge-cup truss. This treatment will, of course, only be successful when the irreducibility depends upon removable causes, such as an increase in the bulk of the omentum or intestine. When due to adhesions and the like, it cannot be thus overcome, though with the use of the hinge-cup truss, adhesions, if not too firm, may gradually elongate and disappear. Seeing, however, that strangulation may occur notwithstanding the use of a truss, other things being equal it is better to advise a radical cure.

3. **Strangulated hernia.**—This form of hernia (Fig. 438) is one in which the protruded portion of intestine or omentum is so tightly gripped, that not only is its return into the abdomen prevented, but the circulation through its blood-vessels is so impeded, that congestion, followed by inflammation and gangrene, ensues if the strangulation is not soon relieved.

Causes.—1. The sudden forcing of intestine or omentum through a ring or aperture so small that it is tightly gripped from the moment of its descent. This is usually the cause of strangulation in a recent hernia or in an old hernia which has suddenly descended through the patient's neglect to put on his truss. 2. The increase of bulk in the hernia subsequent to its descent, and its consequent constriction where it passes through the aperture or ring. This is usually the cause of strangulation in irreducible herniæ, or in herniæ that have not been kept up by a truss. Such an increase in bulk may be induced by: (*a*), the sudden protrusion of a fresh portion

of omentum or intestine on the top of that already down; (*b*), the swelling of the intestine from catarrhal inflammation of the mucous membrane, or from its becoming obstructed by fæces or flatus; and (*c*) congestion and inflammation of the omentum.

The *seat of constriction*, or as it is technically called the *stricture*, is generally either (1), *in the neck of the sac itself*; or (2), *outside the sac*, *i.e.*, at one of the tendinous rings, or other aperture through which the hernia has passed; whilst (3), in very rare instances, it may be *inside the sac*, the intestine having slipped through a hole in the omentum or become entangled by a band of adhesions.

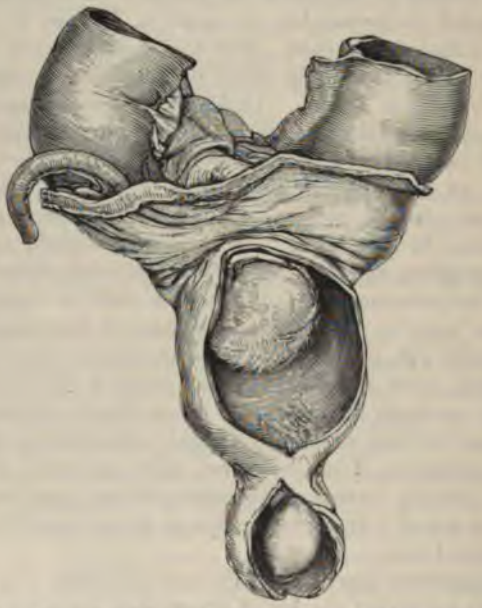


Fig. 438.—Strangulated funicular hernia from a child aged six months. (St. Bartholomew's Hospital Museum, No. 2, 110 *g*.)

Mechanism of strangulation.—The compression of the veins at the seat of stricture impedes the return of venous blood from the protruding portion of intestine or omentum, and the congestion, causing compression of the arteries, ultimately leads to the complete arrest of the circulation, and gangrene finally ensues. The congestion, moreover, induces paralysis of the muscular coat and consequent cessation of its peristaltic action and the onward flow of the intestinal contents. For strangulation to occur it is not necessary for the whole circumference of the bowel to be included in the stricture. An inclusion of only a small portion of its circumference (*Richter's hernia*, sometimes incorrectly called *Littre's hernia*), in consequence of the venous congestion, and subsequent inflammation

which it induces, is sufficient. Indeed, symptoms of strangulation are said to occur when omentum only is contained in the hernia, a fact somewhat difficult to explain, as constriction of omentum by a tight ligature certainly gives rise to no symptoms. It is possible that in these cases the signs of strangulation have depended on reflex irritation of the omental nerves, or on a small knuckle of intestine having been strangulated at the neck of the sac and slipped back unperceived. That strangulation may produce a severe impression on the nerves, is evidenced by the pain reflected to the umbilicus, and by the general nervous symptoms.

Pathological condition of the strangulated part.—When the constriction is very tight, the circulation may be completely arrested, and gangrene ensue in a few hours. But as a rule the arrest is only partial, and the gangrene is preceded by congestion and inflammation. The intestine at first appears red and, perhaps, slightly swollen, but not otherwise altered; whilst clear serous fluid in greater or less quantity is poured out between it and the sac. It next assumes a mulberry colour, and as the congestion increases it becomes darker and darker, and finally black or ash-grey. At the same time it becomes more swollen, and loses its bright shining appearance, becoming sticky, then doughy in consistency, and pitting on pressure, blood is extravasated into it, whilst the fluid in the sac gets darker and turbid, and feculent in odour; finally the intestine sloughs, and its contents are extravasated into the sac. Sloughing or ulceration frequently begins at the seat of stricture, and in the mucous coat, where, even at an early stage, an impression of the stricture is often seen. The omentum undergoes similar changes, passing gradually into a state of gangrene. The intestine, above the strangulated portion for a variable distance, is congested, and distended with fæcal matter, whilst that below is empty and contracted but otherwise natural. Simultaneously with these changes a local peritonitis is set up about the neck of the sac, gluing the intestine to the peritoneum, so that as a rule there is no extravasation into the peritoneal cavity. The sac becomes inflamed, a fæcal abscess is formed, which, if the patient survives, opens on the surface, leaving him with a fæcal fistula. In other cases general peritonitis supervenes, or the intestine gives way above the stricture and so peritonitis results.

The *symptoms* are local and general. *Local symptoms.*—The hernia, if previously reducible, is no longer so; it becomes tender or painful on handling, tense, and often tympanitic; and the *impulse on coughing* is lost. Pain may be present in the hernia, but is generally referred to the region of the umbilicus, that is, over the solar plexus. The skin is usually natural, but where gangrene has occurred, it may become mottled, or brick-dust red, and emphysematous, and exhale a fæcal odour. Cessation of pain may then occur, but is a delusive sign. The *general symptoms* are those of

intestinal obstruction, the two chief being vomiting and constipation. The vomiting is of a peculiar gushing character, with little or no retching. The vomit at first consists of the contents of the stomach, but soon becomes bile-stained, and finally fæcal, *i.e.*, thin and brownish-yellow, with a distinct odour of fæces. The constipation is *complete* (except in Richter's hernia), not even flatus passing, although at first the contents of the large intestine may be voided, either naturally or after an enema. The face becomes pinched and anxious, the pulse small and wiry, the tongue furred and brown, and if strangulation is not relieved, the patient may die of collapse, general peritonitis, or exhaustion from constant vomiting. Very occasionally a fæcal abscess may form and the patient recover with a fæcal fistula. Numerous variations in the symptoms may be met with, but it must suffice to say that as a rule in young patients with recent hernia they are more acute, and call more imperatively for immediate relief than in older patients, the subjects of irreducible hernia of long standing, in whom they assume a more chronic character. Thus the symptoms of strangulation may be ill defined, the patient may only vomit at rare intervals, or on taking food, and the vomiting need not be fæcal. The tongue may remain moist, the abdomen but little distended, and the temperature normal until a few hours before death. The persisting constipation, the tumid abdomen, and a pulse increasing in rate, along with an irreducible hernia, should lead to a diagnosis of strangulation, especially when the patient has had opium.

Treatment.—It cannot be too strongly impressed on the mind of the student that it is of vital importance to release the strangulated intestine; that this as a rule admits of no delay; that every hour adds to the danger (gangrene may occur within twenty-four hours); that the result of the case will depend to a great extent upon the length of time the strangulation has existed; that purgatives for overcoming the obstruction are not only useless but absolutely injurious; and that prolonged and forcible attempts to return the bowel by the taxis are unjustifiable and wholly to be condemned. What should be done, therefore, in a case of strangulated hernia? The taxis should as a rule be applied for a few minutes; if this is unsuccessful the patient should be placed under an anæsthetic, and should the bowel then not slip back readily on again gently trying the taxis, the operation for dividing the stricture should *at once* be proceeded with before he is allowed to recover from the anæsthetic. If the surgeon is not prepared for the operation, or requires help, a full dose of opium should in the meantime be given, and ice, if at hand, or warmth in the form of a large boric acid poultice, be applied to the tumour. But it is better not to attempt the reduction under an anæsthetic till prepared to proceed with the operation. We have then to consider the method of applying the taxis, the cases in which it should not be used, and the operation of herniotomy.

The taxis.—The method of applying the taxis, which is merely the technical term given to the various manipulations of traction and compression used in returning the hernia into the abdomen, can only be learned by practice. The pelvis should be slightly raised, and the thigh, in femoral hernia, flexed and adducted so as to relax as much as possible the constricting ring. With one hand, slightly raise the hernia, and grasp it gently so that some of the flatus or fluid may be squeezed out and the bulk lessened. With the finger and thumb of the other hand, gently compress the neck laterally to prevent its bulging over the margin of the ring, and at the same time draw the hernia a little downwards to disengage its neck. The pressure should be applied steadily, not spasmodically, and its direction varied according to the kind of hernia. No violence should be used, and if after a few minutes the intestine does not slip back with the characteristic rush, further attempts should not be made. Violent or prolonged efforts are strongly to be condemned, as not only are they unlikely to be successful, but may lead to the rupture of the intestine, or stopping short of this, may cause so much bruising, ecchymosis, or inflammation, that they jeopardise its recovery after operation. How long should the taxis be applied? Certainly not more than five minutes at the outside. The length of time, however, may vary in different herniæ. Roughly it may be given at about two minutes for a small tight femoral hernia, and five minutes for a large femoral, inguinal, or umbilical hernia. It should be remembered that the taxis is more successful in recent than in old femoral herniæ; in inguinal than in femoral, and especially in old inguinal under chloroform; and that when successful, it is the safest method of overcoming the strangulation.

The *taxis should not be applied*—1, when other surgeons have already employed it; 2, when the hernia is very tense, tender, or inflamed; 3, in femoral hernia, where fæcal vomiting has existed for some time, or where hiccough has supervened; in short, whenever it appears questionable whether the intestine has not passed into a condition beyond recovery, or whether actual gangrene has not taken place.

Herniotomy has for its object—1, the liberation of the strangulated intestine or omentum by dividing the stricture, and 2, the returning it into the abdomen if proper or possible. The parts having been shaved, thoroughly cleansed with soap and water, and sponged with carbolic lotion (1 in 20) and then with biniodide spirit lotion, an incision should be made over the neck of the sac in the long axis of the tumour, and its coverings carefully and successively divided till the sac is exposed, any bleeding vessels being tied. The sac may be known by the arborescent arrangement of its vessels, its tenseness and smoothness, and, when thin, by intestine, omentum, or fluid being seen through it. It may further be distinguished from the intestine by the shining appearance of the latter, by the

circular arrangement of the intestinal vessels, and by a little fluid usually escaping when the sac is opened. If still in doubt, the questionable structure should be picked up with the thumb and forefinger if not too tense, when, if it is sac, the intestine will be felt to slip away. Before opening the sac, every antiseptic precaution in the widest sense of the term should be taken. All bleeding should be stopped, and the wound, the surgeon's hands and those of his assistant, and the instruments, should be thoroughly cleansed from blood with antiseptic lotion. A piece of the sac should be nipped up with the forceps, and nicked with the blade of the knife held on the flat. If too tense to allow of this, it must be cautiously scratched through with the point of the knife. As a rule there is no danger of injuring the intestine, as some fluid generally exists between the sac and its contents. The sac, however, should always be opened with care, as the intestine may be in contact with it and may spring out. If omentum is seen shining through the sac, it should be opened opposite that spot. The character of the fluid which escapes is a good criterion of the condition of the parts. If pale and serous, the indication is good; if blood-stained and turbid or fæcal in odour, bad. The finger should now be passed through the small opening to protect the intestine, and the sac laid freely open with blunt-pointed scissors, the fluid absorbed by sponges to prevent it running into the abdomen, and the contents examined. If only omentum presents, this should be gently unravelled to search for intestine, a small knuckle of which will often be found near the neck of the sac. The questions will now arise, what shall be done with the intestine, what with the omentum? Shall they, or can they, be returned? Shall the omentum be cut off? Shall the stricture be divided?

Treatment of the intestine.—If the fluid in the sac is of a serous character and the intestine is merely congested and claret-coloured but still shining, and on drawing down the knuckle the spot where it was in contact with the stricture is found normal, there can be no question of replacing the intestine in the abdomen, the finger following it to ensure its entering the peritoneal cavity. If it is already gangrenous (a condition that may be known by its ash-grey colour, loss of elasticity and not bleeding when pricked), there can be no question, on the other hand, that it ought not to be returned, but must be dealt with in one of the ways to be presently described. Again, if it is adherent to the sac the adhesions if soft and recent may be gently broken down with the finger and the intestine returned unless such is contra-indicated from other causes; or if the adhesions are old and fibrous they may be cut through and ligatured, and the intestine also returned; but if they are thick and fleshy, any attempt to break them down would probably lead to the tearing of the walls of the bowel, the adherent portions of the sac under these circumstances should be separated from the surrounding tissues and returned

with the intestine. In cases of the above kind the treatment is clear; but when the intestine is black, ecchymosed, doughy, sticky, or coated with lymph, but not actually gangrenous, whilst the impression of the stricture is marked, and the fluid in the sac is of a dark colour, it becomes an anxious question for the surgeon to decide what to do with the bowel, and much must be left to his own judgment in each individual case. As a general rule it may be said that when only a small knuckle of intestine is present and, although black, has not lost its shining colour, and on gently drawing it down there is no sign of ulceration at the seat of stricture, it should be replaced just within the ring, so that if it subsequently gives way the fæcal contents may escape externally; but that, when the intestine is ecchymosed, doughy, etc., or it is feared that ulceration of the mucous coat may have already begun at the seat of stricture, and especially when a large coil is present, it should be left in the sac, or dealt with in one of the ways to be presently mentioned. Some surgeons, however, if in doubt, always leave the intestine in the sac; others stitch the bowel to the parietal peritoneum, so as to leave the most doubtful part in the centre of the ring of sutures. If the gut gives way the fæces will then pass outwards; if the injured part recovers, the gut will merely be left adherent by one surface to the inside of the abdominal wall. Others again establish a lateral anastomosis between the gut above and below, and should the exposed loop turn out to be gangrenous, remove it the next day and close the ends of the bowel by Lembert sutures.

When the gut is clearly *gangrenous* several courses are open:—

1. An artificial anus may be made (*a*) by merely leaving the gangrenous gut in the sac; or (*b*) by cutting away the gangrenous part; or (*c*) by cutting it away and stitching the open ends of the intestines to the wound. A secondary operation will subsequently be required to close the artificial anus (p. 912).

2. The gangrenous part may be cut away; and the intestine above and below united and returned into the abdomen. When this course is selected some surgeons are in favour of uniting the gut in the wound; others through an incision in the middle line or linea semilunaris. When the mesentery is sufficiently long to allow of the intestine being drawn down, the wound is the better situation. When the intestine cannot be drawn down, as in some cases of femoral hernia, then the abdominal incision is perhaps preferable. In inguinal hernia, the wound can be readily prolonged into the abdominal cavity. In femoral hernia to do this would involve the division of Poupart's ligament and the subsequent weakening of the abdominal wall in this situation. Whichever method is chosen sufficient intestine should be cut away to ensure sound tissues being brought into contact. The peritoneal cavity being protected by aseptic gauze packed round the loop of intestine to be dealt with, cut the gangrenous portion completely away; empty the distended

portion above as much as possible; clamp both the upper and lower portions with Makin's clamp or rubber tubing passed through a small incision in the mesentery, to prevent further fæcal soiling: irrigate with perchloride of mercury solution (1 in 2,000); restore the continuity of the gut by one of the methods described at p. 537, and replace the united intestine in the abdominal cavity. Remove the sac after ligature of its neck, and close the ring or the abdominal wound in the ordinary way if the operation has been done by the intra-abdominal method.

The choice of establishing an artificial anus, or of excising the gangrenous portion and uniting the gut above and below, will depend in great measure on the general condition of the patient, and on what assistance and appliances for an aseptic operation are at hand.

Should the intestine be accidentally wounded either in opening the sac, or, as more commonly happens, in dividing the stricture, the edges of the wound should be united in the way described at p. 533.

Treatment of omentum.—When small in amount, recently protruded, and only slightly congested, the omentum should be returned. When large in amount, thickened, inflamed, or gangrenous, it should be ligatured, cut off, and the stump returned into the abdomen. Aseptic silk is the best material for ligaturing the omentum. The ligature, to prevent slipping, should be tied very tightly and be made to transfix the pedicle, the latter, if necessary, being gently pulled down to ensure its being tied at a healthy spot. Too fine a ligature should not be used, lest it cut through the delicate omentum. When the omentum forms a large mass it should be carefully unravelled to determine the absence of intestine in its midst, drawn down until a healthy portion is met with, and then tied in separate portions with stout silk, interlocking the sutures. Ligature of the vessels separately is unsafe, as some may be missed, and hæmorrhage occur into the peritoneal cavity. The ligatures should be cut off short and returned with the omentum. They become encysted and cause no irritation. If the omentum is adherent to the intestine it is gently separated from it, or if too adherent cut away, leaving the adhering portion to be returned with the intestine. If adherent to the sac it may be separated and returned or removed with the latter.

Division of the stricture at the neck of the sac.—Pass the index finger gently between the intestine and the sac, or if the omentum is spread out between the intestine and the sac (forming the so-called *omental sac*), between the sac and omentum. The stricture having been discovered, insinuate the finger-nail gently under it, and the intestine being held aside by the other fingers or by an assistant, pass the hernia knife (Fig. 439), held with its blade on the flat and protected by the pulp of the finger, beneath the

stricture, turn its cutting edge towards the stricture, and notch the latter in one or more places by gently depressing the handle. The direction in which the notch should be made will depend upon the situation of the hernia ; in extent it should be as limited as possible. The surgeon, as a rule, will do better to employ his finger than the director, as there is much less risk of wounding the intestine ; but if a director is used it should be broad and flat (Fig. 440) so as to prevent as much as possible the intestine bulging or springing over it, and so coming into contact with the edge of the knife. If it is found that the stricture is not sufficiently divided to allow the

Fig. 439.—Cooper's hernia knife.

intestine to slip back on being manipulated with the fingers, a second notch should be made. But if the intestine does not then return easily the stricture should be divided again, as no force must be used. Before returning the bowel it should, of course, be gently drawn down and examined for possible ulceration at the line of stricture. Instead of dividing the stricture from within outwards, in inguinal hernia the incision may be made over the internal ring, and the stricture then divided from without inwards. Every step is plainly in view, and no hernia knife or director is required.

Where the intestine is gangrenous, some surgeons, who hold that it is better to leave the gangrenous intestine in the sac, merely notch

Fig. 440.—Key or Wormald's hernia director.

the stricture, disturbing as little as possible the adhesions that have formed between the intestine and the neck of the sac, as it is upon these cutting off, as they do, the general peritoneal cavity from the gangrenous gut, that the patient's safety depends. If this course is pursued the stricture had better be divided from without inwards, so that neither the finger nor the director need be pushed up from the septic sac into the abdomen. If the ring is thus treated the peritoneal adhesions may be left undisturbed. The division here is not practised for the purpose of relieving the strangulation, as the bowel is already dead ; but for the purpose of allowing the contents of the bowel above the gangrenous part to escape externally. The results of this plan are, however, thought by some surgeons to

be more fatal than resection; should the patient survive, even then he has an artificial anus to be cured.

Treatment of the sac.—The next question that arises is, what should be done with the sac? The general practice, unless contra-indicated, is to dissect up the sac, apply a silk or stout catgut ligature to its neck, and cut the body of the sac away. In *inguinal* hernia the ring may then be brought together with sutures, and the wound closed. If the hernia is very large a drain-tube may be passed through a small incision in the bottom of the scrotum to insure an efficient drain. In *femoral* hernia the parts are so rigid that they are with more difficulty brought together. In *umbilical* hernia the sac with the redundant integuments may be removed, and the wound united with the peritoneal surfaces in contact by deep and superficial sutures. The sac should not be ligatured and cut off—1. When the patient is weak or collapsed, and it is desirable to complete the operation with as little delay as possible. Here the wound may be quickly filled with antiseptic gauze and thus left. 2. When the intestine is in that doubtful condition that it has only been placed just within the ring. Here a large drain-tube may be inserted and packed round with gauze, so that should the intestine give way the fæcal contents can readily escape. 3. When the abdomen contains much serous fluid, or peritonitis is present—a gauze drain or tube may then be inserted.

After-treatment.—The wound should be dressed antiseptically, and a spica bandage firmly applied. Half a grain of morphia may then be injected subcutaneously; with this some surgeons combine atropine (gr. $\frac{1}{100}$). Some surgeons keep the patient subsequently under the influence of the drug, in order to place the intestine at rest till it has had time to recover from the effects of the inflammation; others only employ it if there is pain or restlessness. To further insure rest some wash out the stomach with the syphon-tube, but this is not as a rule desirable, as it increases the shock of the operation. With the same end in view no nourishment should be given by the mouth for the first twelve or twenty-four hours, but teaspoonfuls of hot water may be sipped occasionally to relieve thirst and check any tendency to vomit. Nutrient suppositories (Slinger's are perhaps the best) or nutrient enemata (milk, ℥ij.; beef-tea, ℥j.; egg, j.; peptonizing powder, ʒj.) after the first twelve hours may be given by the rectum. Subsequently milk, in small quantities at a time (℥j. of water at first every two hours), may be taken by the mouth, then, in addition, beef-tea; but no solid food should be allowed till the bowels have acted. This they should usually be permitted to do spontaneously, as no harm will ensue should they continue confined for a week or ten days. If, however, any distension or uncomfortable sensations are experienced, an enema of soap and water may be given on the second or third day, or the rectal tube passed to permit of the escape of flatus, and a change of position in bed

allowed. If the distension is great a purge on the third day may sometimes be given with advantage; such, however, is seldom required, and is not warranted if the intestine was found at the operation to be in a doubtful condition.

Conditions that may give rise to a continuance of the symptoms of strangulation after the taxis or herniotomy.—As a rule the symptoms of strangulation cease immediately or soon after the successful application of the taxis, or of herniotomy. Should they persist they may depend on—1. The effect of the anæsthetic. 2. Paralysis of the muscular coat of the intestine. 3. The presence of another hernia. 4. The displacement of the hernia into the loose tissue outside the peritoneum, "properitoneal hernia," or reduction *en masse*. 5. Detachment of the neck of the sac, the intestine remaining strangulated. 6. Rupture of the sac, and reduction of the intestine through the rent, the strangulation continuing at the neck. 7. Passage of the intestine into a pouch or second sac instead of into the abdominal cavity, "bilocular hernia." 8. Incomplete reduction of the intestine. 9. The gut becoming gangrenous and giving way. 10. Enteritis or peritonitis. 11. Internal strangulation of the intestine by adhesion probably near the neck of the sac, which may happen when the bowel has been often reduced by the patient. 12. A combination of volvulus with hernia, the volvulus having formed in the sac and being reduced untwisted, or the volvulus develops in the abdomen from the dragging of the hernia, or after reduction owing to the paralysis of the bowel.

If the persistence of the symptoms is due to the anæsthetic they will probably pass off in a few hours. The vomiting, moreover, is usually attended with much retching, and is not of that gushing nature characteristic of strangulation of the bowel. If due to paralysis of the muscular coat of the intestine, the symptoms also, as a rule, gradually cease as the congestion passes off. Should they not do so, however, a careful search should be made, if this has not already been done, for another hernia, and if one is discovered and appears strangulated, it should be explored. If no other hernia exists the continuance of the symptoms may be due to the hernia not having been properly reduced, to peritonitis, to the persistence of the paralysis of the muscular coat of the gut, or to internal strangulation. If, therefore, the hernia is reported not to have slipped back with the usual gurgle, or there is some fulness felt about the hernial ring, the ring must be cut down upon and explored, or the wound, if an operation has been performed, opened up. It may then (Fig. 441) be found (*a*) that the hernia has been reduced *en masse*, *i.e.*, that the hernia, along with the sac, has been forced between the fascia transversalis and the peritoneum, a condition which is most frequently met with when the hernia is inguinal, and which has often been produced by the patient himself before being seen by the surgeon; (*b*) that the neck of the sac has become

detached, the intestine in the abdominal cavity remaining strangulated by it; (*c*) that the posterior part of the sac has been rent and the hernia, still strangulated at the neck, forced into the subserous connective tissue; or (*d*) that the hernia has been only reduced from the outer to the inner pouch of a bilocular hernia instead of into the peritoneal cavity (see Fig. 441, 3); (*e*) that the intestine has not been completely reduced. Under any of the above circumstances the finger should be introduced into the sac. If it *can* be passed through the neck into the abdominal cavity the continuance of the symptoms will probably depend on (1) paralysis of the muscular coat consequent on injury of the intestine; (2) reduction into a pouch at the neck of the sac; or (3) strangulation by adhesion within the abdomen. In such cases the portion of intestine at fault will probably be in the near vicinity of the neck of the sac, and can be

FIG. 441.—Hernia. Incomplete reduction, after Moynihan. *a*. Bowel. *b*. Sac. *c*. Parietes. 1. Reduction *en masse*. The sac, still retaining the strangulated hernia, has been forced backwards between the fascia transversalis and the peritoneum. 2. The sac has been ruptured and the coil of gut, still strangulated, forced into the subperitoneal tissue. 3. The hernia has been reduced from the outer into the inner sac of a bilocular hernia where it still remains strangulated.

drawn down by the finger and inspected. If the finger *cannot* be passed into the abdominal cavity the trouble will most likely depend upon (1) a reduction *en masse*; (2) detachment of the neck; (3) a rent of the sac; or (4) incomplete reduction. Try to feel the neck of the sac with the finger. If this cannot be felt then the neck of the sac has been detached and pushed backwards, and the condition is one of reduction *en masse*. If the neck can be felt, but there is no passage into the abdomen, then the contents of the sac have probably been forced through a rent in the sac into the surrounding tissues. The sac should then be drawn down, the condition causing the strangulation accurately ascertained, the stricture, wherever situated, divided, and the intestine returned into the peritoneal cavity.

Peritonitis following the reduction of a hernia may be known by the signs already given at p. 549, and should be treated as there indicated. Persistent paralysis of the muscular coat, or the existence

of internal strangulation, may be suspected when along with the continuance of the symptoms of strangulation of the bowel the signs of the other conditions that may give rise to such symptoms are absent. Should the paralysis not pass off under the influence of time, an enema, or even a purgative, may, in some cases, be useful to rouse the intestine to action, whilst, in rare instances, it may become necessary to explore the abdomen, open the intestine above the paralysed part, and suture it to the wound in the parietes. Internal strangulation should be treated as described under *Laparotomy*.

Prognosis.—The prognosis in a case of strangulated hernia will depend on the length of time the hernia has been strangulated, the tightness of the stricture, the presence or absence of peritonitis or gangrene before the operation, the amount of bruising inflicted on the gut by the taxis, the degree of exposure and manipulation to which the gut is subjected during the operation, and the general condition of the patient. Moreover, the prognosis is graver in a small femoral hernia, and in a hernia which has recently come down (inasmuch as in these the constriction is usually tight), than in an oblique inguinal hernia, or a hernia of long standing, in which the constriction is usually much less severe.

4. **Obstructed or incarcerated hernia.**—These terms are generally applied synonymously to an irreducible hernia in which the protruded intestine has become obstructed by a collection of undigested food, foreign bodies, as fruit-stones, etc. This condition is most frequently met with in old people, especially women, and in umbilical herniæ, and if neglected, is apt to become strangulated or inflamed. *Symptoms.*—As in strangulation, there may be constipation, colicky pains, nausea, and perhaps vomiting; but the local signs of strangulation are less marked. Thus, there may be little or no local pain and no tension in the sac, though, at times, it may become larger than before the incarceration occurred. The impulse on cough may still be present, and hard fæcal masses may, perhaps, be felt. The symptoms, however, may gradually merge into those of strangulation, and it is often difficult to distinguish mere obstruction from strangulation, especially when the former is associated with some inflammation of the sac. When in doubt, the case should be treated like one of strangulated hernia. *Treatment.*—A purgative enema, rest in the recumbent position, warmth or ice to the part, and restriction of diet should be prescribed. When there is no vomiting, a brisk purge is often successful, but before giving such the surgeon should thoroughly assure himself that strangulation does not exist. The application of the taxis is advised by some, and doubtless the intestine at times may be emptied of its contents by this means. It should be remembered, however, that its use is not unattended with risk.

5. **Inflamed hernia.**—In this condition the sac and, in some

degree, its contents are inflamed. Inflammation is most common in small irreducible epiploceles, and is generally the result of injury, the pressure of a badly-fitting truss, or of violent exercise. If neglected the hernia is apt to pass into a condition of strangulation.

The *local symptoms* resemble those of a strangulated hernia, but the impulse on cough is not absent, though it may be less marked than in a hernia in its ordinary state, and there is not so much tension in the sac as when strangulation exists. The parts are hot, tender, and œdematous, and there may be feverish symptoms, vomiting, and constipation. The vomit consists, however, only of the contents of the stomach, and is not fæcal; the constipation is seldom complete; and flatus usually passes.

Treatment.—An ice bag should be applied over the hernia, and the patient placed in the recumbent position, with the parts as much as possible relaxed. The diet should be restricted to small quantities of milk and beef-tea, and opium administered in small doses. When all signs of inflammation have subsided an enema may be given if the bowels do not act spontaneously. Should the inflammation run on to strangulation, herniotomy must be performed; whilst, should suppuration, a very rare event, occur, the pus must be let out by a free incision.

Fæcal fistula and artificial anus after operation for strangulated hernia.—Fæcal fistula is due to ulceration of the mucous membrane at the seat of stricture, and subsequent perforation of the bowel; artificial anus, to the gangrene of a considerable portion of the strangulated bowel. In both, adhesions form between the serous coat of the intestine and the parietal peritoneum, and in this way prevent the extravasation of fæces into the general peritoneal cavity; but in the fæcal fistula the perforation of the bowel being small, most of the fæcal contents are passed per anum; whereas, in artificial anus, the whole escape externally, and the intestine below shrinks and becomes more or less atrophied. In fæcal fistula only a fistulous aperture, discharging fæces, is present; in artificial anus the openings of the upper and lower portions of the intestine can generally be seen. The upper opening may be known by its larger size, redder colour, and by fæces issuing from it, whilst at times its mucous membrane may be prolapsed.

Treatment.—A fæcal fistula will, as a rule, close spontaneously, and beyond keeping the parts clean, nothing is generally required. In artificial anus the spur-like process or *éperon* formed by the projecting forwards of the posterior wall of the bowel by the coils of intestine which lie in the angle between the upper and lower portions of the intestine, may have first to be destroyed by Dupuytren's enterotome, and the lumen of the bowel being thus restored, the artificial anus may be closed by a plastic operation, or the walls of the bowel united by suture. The enterotome consists of two blades,

one of which is passed into each portion of the bowel. By a screw arrangement the blades are then tightened and the intervening portions of the walls of the gut are slowly destroyed. The blades should not be passed far into the bowel for fear of including a knuckle of intestine which might happen to have descended into the angle of the spur between them. The surgeon, however, should not be in too great haste to employ the enterotome, as in the course of time, in consequence of the dragging of the mesentery, the spur-like process may become gradually retracted, and the two portions of intestine, instead of lying parallel, may be drawn to more or less of an angle with each other. In this way the lumen of the tube may become gradually restored, and the fæces again pass down the lower tube. A plastic operation will then only be required to close the external opening, if indeed this does not heal spontaneously, as in fæcal fistula. Thus, a ring of skin half an inch wide should be removed from around the opening, the adherent intestine separated from the parietes, the mucous membrane turned inwards, the raw intestinal walls united by non-penetrating sutures, and the refreshed surfaces of the parietes brought into contact by deep sutures. In some cases, as when there is much inflammation or eczema of the skin around the mouth of the fistula, it may be better to open the abdomen at some little distance from the fistula where the skin is healthy and establish a lateral anastomosis between the upper and lower bowel. The external opening will then close spontaneously or may be closed by a plastic operation.

Special Herniæ.

The three most common forms of hernia are:—the inguinal, the femoral, and the umbilical. Of the rarer forms may be mentioned the obturator, the ventral, the epigastric, the diaphragmatic, the lumbar, the ischiatic, the perineal, the vaginal, and the rectal.

Inguinal hernia is one which escapes into or through the inguinal canal. Of this form there are three chief varieties, the oblique or external, the direct or internal, and the interstitial in which there is a second sac extending between the abdominal parietes.

The oblique or external variety is so called because it descends *obliquely* through the inguinal canal, and leaves the abdomen *external* to the deep epigastric artery. The hernia enters the canal by the internal abdominal ring, and may remain in the canal, when it is spoken of as *incomplete*, or, from its resemblance to a bubo, as a *bubonocele;* or it may pass through the canal and out of the external abdominal ring, when it is said to be *complete*, and is then termed a *scrotal* or *labial* rupture, according as it descends into the scrotum or labium. The *coverings* of an oblique inguinal hernia differ according as it is complete or incomplete, or occurs in the male or in the female. When *complete and in the*

male they are, from without inwards, 1, skin ; 2, superficial and deep fascia ; 3, intercolumnar fascia ; 4, cremasteric fascia ; 5, infundibuliform process of the fascia transversalis ; 6, subperitoneal fat ; and 7, peritoneum, which constitutes the sac. In the *female* the cremasteric fascia is wanting, otherwise the coverings are the same. In the *incomplete* the only difference in the coverings is that in place of the intercolumnar fascia there is the aponeurosis of the external oblique, and in place of the cremasteric fascia the lowermost fibres of the internal oblique and transversalis ; they are the same in the male and female. The *stricture* when the hernia is strangulated is usually in the neck of the sac, and this may be situated at the external abdominal ring, the internal abdominal ring, or anywhere in the inguinal canal between the two rings. The bladder is often dragged into the hernia, either into the sac or buried in the sac wall.

Varieties of oblique inguinal hernia.—These will perhaps be better understood by reference to the accompanying diagrams. The following are those most commonly described :—

Fig. 442.—Ordinary acquired inguinal hernia. (Bryant's Surgery.)

Fig. 443.—Congenital inguinal hernia. (Bryant's Surgery.)

1. The *common* or *acquired form* (*the inguino-scrotal of Birkett*). —The sac here consists simply of a protrusion of peritoneum through the inguinal canal, and the hernia when complete may descend into the scrotum or labium. The testicle can be felt either below or below and behind the hernia (Fig. 442).

A hernia in a young child may be congenital as regards time, having been noticed shortly after birth, yet is more often of the common so-called acquired type, the sac being in front of the vas deferens and above, not continuous with the tunica vaginalis testis. Hamilton Russell holds that the sac in such cases is not formed by a special process of peritoneum but is the persisting upper end of the funicular process.

2. The *congenital*.—In this form the hernia descends into the funicular process of the peritoneum, which has remained open, and comes into contact with the testicle, the funicular process and tunica vaginalis of course forming the sac. The testis is more or less surrounded by the hernia, instead of being felt distinctly behind and below it, as in the former variety (Figs. 442 and 443). Such a hernia may appear for the first time after puberty.

3. The *hernia into the funicular process* resembles the congenital, in that the hernia descends into the funicular process of the tunica vaginalis, but differs in that it does not reach the testicle, being cut off from it by a septum at the epididymis. Should an operation be required in this form, the testicle is not seen as in the congenital.

4. The *encysted congenital* (Fig. 445).—In this form the funicular process of the tunica vaginalis is cut off from the peritoneal cavity by a septum at the internal ring. The septum yields to the pressure of the hernia, and becomes invaginated before it into the unobliterated funicular process, which is nearly always distended with fluid (*infantile hydrocele*) and consequently may obscure the evidence of a hernia. Should an operation be necessary, the anterior layer of the funicular process, and the elongated septum forming the spurious sac, will have to be cut through.

Fig. 444.—A congenital inguinal hernia. The roll of paper is that originally placed in the specimen by Percivall Pott. (St. Bartholomew's Hospital Museum.)

Fig. 445. — Encysted congenital hernia. (Bryant's Surgery.)

Here, as in the funicular variety, the hernia is not in contact with the testicle.

5. The *infantile hernia* is one in which the intestine, enclosed in its sac, descends behind the funicular process of the tunica vaginalis, which has remained unobliterated and distended with fluid (*infantile hydrocele*), but is cut off by a septum at the internal abdominal ring from the general peritoneal cavity. Should an operation become necessary, three layers of peritoneum have to be cut through, viz., the anterior layer of the unobliterated funicular process of the tunica vaginalis; the posterior layer of the same; and finally the true sac. The last two, however, are generally intimately blended, so that there are apparently only two layers to cut through. These layers are separated by the hydrocele fluid which escapes when the anterior layer is divided, and may lead the surgeon into the mistake that the true sac has been opened.

The direct or internal inguinal hernia is so called because

it escapes *directly* through the external abdominal ring without traversing the internal ring and the whole length of the canal, and is situated *internal* to the deep epigastric artery. Before escaping at the external abdominal ring it either passes through or under the conjoined tendon of the internal oblique and transversalis, which is situated immediately behind the external abdominal ring; or it protrudes that structure in front of it. The *coverings* from without inwards are: 1, skin; 2, superficial and deep fascia; 3, intercolumnar fascia; 4, transversalis fascia; 5, subperitoneal fat; and 6, peritoneum forming the sac. When the conjoined tendon is protruded in front of the hernia, this of course constitutes an additional covering, and will then be found between the intercolumnar and transversalis fasciæ. It will thus be seen that the coverings of the direct hernia differ from those of the oblique, in the absence in the former of the cremasteric fascia, and in the substitution of the transversalis for the infundibuliform process of that fascia. The spermatic cord with its coverings from the cremasteric and infundibuliform fascia lies to the *outer* side. From what has been said above, it will be seen that the epigastric artery is situated on the inner side of the neck of the sac in the oblique; on the outer side in the direct. The *stricture* when the hernia is strangulated is generally in the neck of the sac, and this may be situated at the external abdominal ring or at the aperture in the conjoined tendon through which the hernia has passed.

Two *varieties* of direct inguinal hernia are described according as the protrusion takes place internal or external to the obliterated hypogastric artery, but are not of sufficient importance to be described here.

A direct hernia may also extend inwards forming a properitoneal, prevesical pouch.

Signs and diagnosis of inguinal hernia.—There is a swelling in the inguinal region having the general characters of hernia already given. When *incomplete* the swelling will be in the groin, and has to be chiefly distinguished from enlarged inguinal glands, a femoral hernia, encysted hydrocele of the cord, non-descended testicle, abscess in the inguinal canal, and, in rare instances, from fatty and other tumours of the cord. When it is *complete*, *i.e.*, has passed into the scrotum, the diagnosis has to be made from hydrocele of the tunica vaginalis, hæmatocele, solid tumours of the testicle, and varicocele. 1. In *enlarged glands* the canal is free, the glands are felt in front of it, and some cause is present to account for their enlargement. 2. In *femoral hernia* the swelling is external to the spine of the pubes, the neck of the hernia is below Poupart's ligament, the inguinal canal is free, but the hernia can be felt through its front wall, and to return it pressure must be made in a direction downwards, backwards, and then upwards. In inguinal hernia, on the contrary, the swelling is internal to, or covers the

spine of the pubes; the neck is above Poupart's ligament; the inguinal canal is occupied by it, and to return it pressure must be made upwards and outwards. 3. In *encysted hydrocele of the cord* the swelling is translucent, tense, oval, and well-defined, and it cannot be returned into the abdomen. There is no expansile impulse on cough. 4. In *retained testicle* that organ is absent from the scrotum; there is no impulse on cough; testicular sensation can be obtained by pressure on the swelling; and the swelling cannot be returned into the abdomen. If the testicle is inflamed or the cord is twisted (see *Torsion of the Spermatic Cord*), vomiting may be present, but it has not the gushing character of the vomiting of hernia, and constipation, if also present, is not complete. There may, however, be a strangulated hernia in addition to an

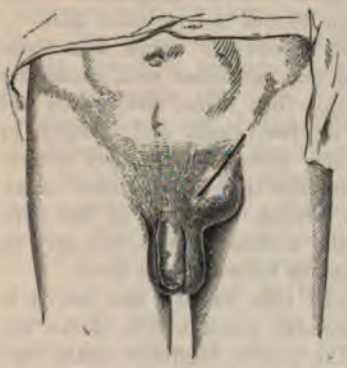


FIG. 446.—Direct inguinal hernia, with line of incision.

FIG. 447.—Oblique inguinal hernia left side, direct right side, with lines of incision.

inflamed testicle. The diagnosis in such a case is very difficult. If in doubt an exploratory incision should be made over the tumour. 5. In *hydrocele of the tunica vaginalis* the tumour is translucent, tense, and semi-fluctuating; there is absence of impulse on coughing, freedom of the cord, and a history of it having begun at the bottom of the scrotum. In infants, however, a hernia may be translucent, and in a hydrocele of the congenital variety the fluid can be pressed back into the abdomen, but it does not return with the gurgle or slip characteristic of a hernia. 6. In *varicocele* the dilated veins can be felt in the scrotum, and the impulse on cough has a thrill-like character. A varicocele, like a hernia, is reduced on the patient lying down, but if the finger is placed firmly over the ring, the veins, on the patient rising, refill, notwithstanding the pressure of the finger, whereas a hernia would remain reduced. The *indirect* hernia cannot be distinguished from the *direct*, when the rings get dragged opposite one another, except by the pulsations

of the deep epigastric artery just within the ring, the artery being internal to the oblique and external to the direct. The indirect is more common in the young, the direct in the old.

Treatment.—What has already been said on this subject with regard to hernia generally is applicable here, and it need only be added that if an operation is necessary the incision (Figs. 446 and 447) should be made downwards and inwards, over the long axis of the hernia, beginning just above the external abdominal ring, or at the internal ring if it is decided to divide the stricture from without inwards (see p. 906); and that the stricture, whether the hernia be direct or indirect, should be divided *directly upwards*, so as to avoid the epigastric artery.

Bilocular hernia is a hernia in which the sac is divided into two loculi communicating by a single orifice with the abdominal cavity (Fig. 441, 3, p. 910). Mr. Moynihan divides the varieties into—

(1) *Properitoneal or intraparietal*, where the upper and inner loculus lies between the peritoneum and muscular wall, extending upwards towards the anterior superior iliac spine, downwards and backwards towards the iliac fossa, or downwards and inwards in front of the bladder. The outer and lower loculus may extend downwards into the scrotum or not further than the inguinal canal. It is generally congenital in origin, arising from one of the peritoneal fossæ on the inner aspect of the abdominal wall, but may be acquired, either by reduction *en masse*, or by wearing a truss.

(2) *Interstitial or interparietal.*—In this variety the hernia is generally connected with an undescended testis which blocks the way, one loculus being formed by the tunica vaginalis testis, and the other extending upwards between the external and internal oblique. But it may occur in women, or in men with a normally descended testis. Generally the external abdominal ring is closed, and behind and above it a rounded or oval, somewhat flattened swelling extends upwards and outwards towards the anterior iliac spine. If the hernia can be reduced, the testis, small and soft, is then felt in the inguinal canal, and an attempt to apply a truss causes pain. Indeed, the testis may undergo inflammation and strangulation although the hernia can be reduced.

In bilocular hernia strangulation may occur at the opening into the peritoneal cavity and at the orifice of the lower and outer sac. Taxis is likely to result in incomplete reduction or reduction *en masse*. In operating it is absolutely necessary to reach the neck of the sac where it joins the peritoneal cavity and to remove the sac up to this level. When combined with retained testicle a truss with a <-shaped pad should be worn if practicable above the testicle. If the truss causes the testicle to become frequently inflamed, the testicle had better be removed (see *Retained Testis*).

Retroperitoneal hernia.—The cæcum or sigmoid flexure may slide up and down behind the peritoneum, "*Sliding hernia*,"

"*Hernie par glissement.*" The gut may apparently be pushed back with ease, but forthwith returns underneath the truss. On exposing the hernia, no sac or only a partial sac may be met with; hence care is necessary not to hastily injure the gut. The partial sac may be raised as a flap and stitched over the bowel where it is uncovered by peritoneum, which is then completely returned to the abdominal cavity.

The operation for the cure of inguinal hernia by excision of sac and suture of the ring is now one of great frequency, and the good results are seen in the diminution of cases of strangulation. In order to avoid a recurrence, many methods of performing the operation are being continually devised. Whilst all these methods are usually successful, none are as yet perfect. The smaller modifications are innumerable, varying with individual surgeons, and surgeons have necessarily to introduce modifications to meet the variations presented by different cases, for it is proverbial that no two cases of hernia are alike. Even when bilateral there are always differences to be noted between the two sides. It cannot be said that any special method is the most efficient, nor suitable for every case. The various methods may be divided into two groups, Macewen's operation being taken as the type of the one and Bassini's of the other. The essential points for success are—(1) the removal of the whole sac including the neck; and (2) the closure of the upper end of the inguinal canal. The best material for the buried sutures is kangaroo-tail tendon or silk.

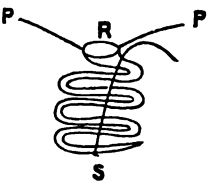


FIG. 448.—Method of folding up the sac in Macewen's method of radical cure of hernia. S. Sac. R. Internal abdominal ring. P P. Parietal peritoneum.

(1) *Macewen's method.*—Macewen dissects up the sac and frees it as far as the internal abdominal ring by introducing his finger along the inguinal canal. The internal ring having been reached, the peritoneum is separated for about half an inch from the whole of the abdominal aspect of the circumference of the ring. The external oblique is not divided. A stitch is firmly secured to the distal extremity of the sac and a needle carrying the suture is passed in a proximal direction several times through both layers of the sac, so that when pulled upon the sac becomes folded upon itself like a curtain (Fig. 448). The needle is then brought out through the anterior abdominal wall just above the internal ring, and the folded sac having been pushed through the ring in the transversalis fascia is secured there by the suture. The internal oblique and transversalis muscles are now drawn under Poupart's ligament and there fixed by a suture so as to close the internal ring, the aponeurosis of the external oblique being avoided so that its elastic recoil shall not draw open the canal. The external

abdominal ring is then laced up and the skin-incision closed in the usual way.

Modifications.—(*a*) *Stanmore Bishop's method.*—Stanmore Bishop

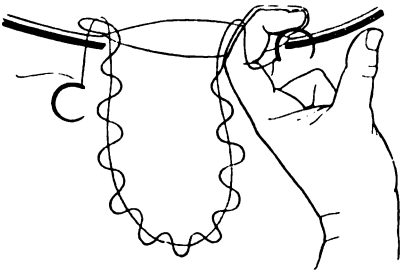


Fig. 449.

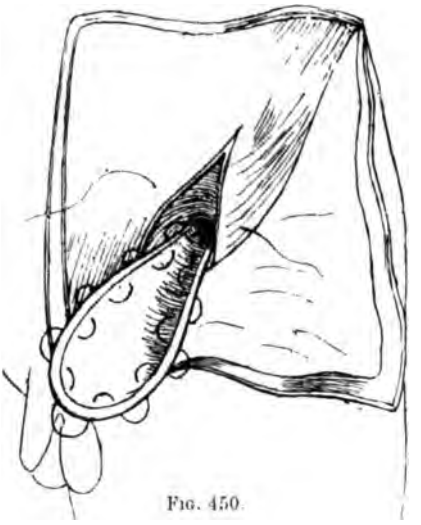


Fig. 450.

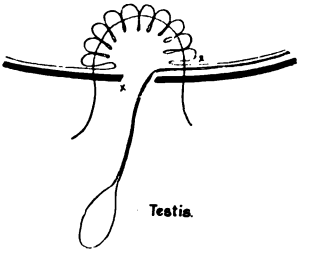


Fig. 451.

Figs. 449, 450 451.—Method of treating the sac in Stanmore Bishop's method of radical cure of hernia.

dissects up the sac and frees it from the surrounding structures as far as, but not beyond, the internal abdominal ring. A long suture, armed at both ends by needles, is now passed from below upwards through each wall of the sac in such a way that, when the ends are pulled upon, the sac is drawn up, not like a curtain as in Macewen's operation, but like a purse (Fig. 449). The neck of the sac is next invaginated on one side before the finger, and the needle belonging to the end of the thread on that side passed through the internal ring and made to pierce the abdominal wall from within outwards (Fig. 450). The same thing is done on the opposite side. When both threads are presenting through the muscular structures

Fig. 452.—Kocher's method of radical cure of hernia. (Jacobson.)

Fig. 453.—Kocher's method of radical cure of hernia. (Jacobson.)

(Fig. 450) they are pulled up, the sac being at the same time invaginated before the finger as the threads are drawn upon. The sac is then turned inside out in its passage and becomes fixed as a rounded boss exactly over the internal ring, its peritoneal surface being turned towards the intestine and its first fold on either side being firmly applied to the peritoneum immediately within the ring (Fig. 451). The ends of the thread are now tied firmly, but not tightly, over the ring, which with the canal is then further closed by buried sutures, so placed as to draw the superior half of the anterior wall of the canal and internal pillar of the external ring well over in front of the inferior half and external pillar.

(*b*) *Barker's method.*—Barker dissects out only the neck of the sac, ligatures it and cuts it through half an inch below the ligature. The scrotal portion of the sac is removed. The neck of the sac is

fixed to the abdominal wall by the same ligature that closes the internal ring. The external abdominal ring is next laced up as usual.

(*c*) *Ball's method.*—Ball, of Dublin, after dissecting out the sac, recommends torsion or twisting before ligaturing the neck and cutting off the body of the sac. Care must be exercised in applying torsion since the peritoneum has been drawn down and the bladder pulled into the wound.

(*d*) *Kocher's method* consists in dissecting out the sac and in then passing a dressing forceps through a small incision in the aponeurosis of the external oblique and fibres of the internal oblique external to the deep abdominal ring (Fig. 452). The sac is seized by the forceps, drawn out of the incision in the aponeurosis (Fig. 453), twisted up into a cord and laid down between the pillars of the external

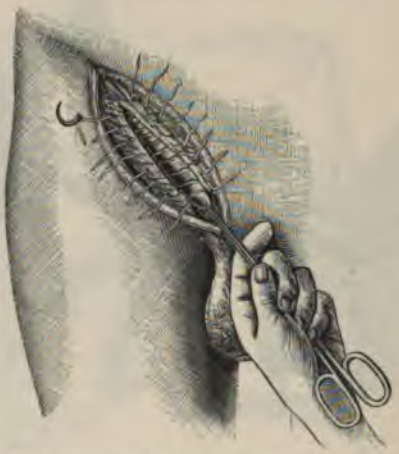


Fig. 454.—Kocher's method of radical cure of hernia. (Jacobson.)

abdominal ring, where it is fixed by the sutures used to draw the pillars of the ring together (Fig. 454).

(*e*) *McBurney's method.*—McBurney, of New York, treats the wound by open incision after dissecting out and ligaturing the sac. He endeavours to keep the wound an open one by turning in the integument and suturing it to the deep fascia. He then packs it with iodoform gauze and allows the wound to granulate. The wound takes from three to six weeks to heal, but the firm scar left completely obliterates the inguinal canal.

(2) *Bassini's method.*—This is a method recently much used. An incision is made from the internal to the external ring parallel to and about $\frac{3}{4}$-inch above Poupart's ligament. The external ring having been defined, the aponeurosis of the external oblique is divided from the apex of the ring the whole length of the skin-incision. The sac is next defined, cleared with the finger as high as

the internal ring, the neck ligatured and the body cut away. The cord is now lifted out of the inguinal canal and held aside (Fig. 455). The internal oblique, with the transversalis and transversalis fascia, is next separated from the aponeurosis of the external oblique and from the peritoneum, and sewn by four or five silk or kangaroo-tail sutures to the deep internal surface of Poupart's ligament, which should have been previously defined. In Fig. 455 two of the sutures (D E) are seen *in situ*. When all the sutures have been passed they are tied beneath the cord and thus pull the conjoined tendon of the internal oblique and transversalis with the transversalis fascia firmly downwards and outwards, and so form a firm

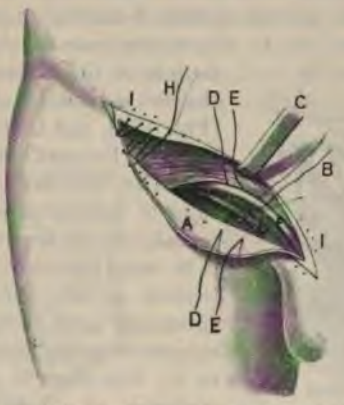


FIG. 455.—Method of applying the sutures in the radical cure of hernia by the modified Bassini method. A. Aponeurosis of external oblique turned down. B. Silk ligature holding spermatic cord F aside. C. Director retracting the upper margin of the divided aponeurosis of the external oblique. D and E. Two of the deep sutures passed through the deep internal surface of Poupart's ligament and conjoined tendon. G. The conjoined tendon of the internal oblique and transversalis and transversalis fascia. H. Continuous suture for sewing up the divided aponeurosis of the external oblique. I I. The skin in which some of the spots are indicated at which the skin sutures should be passed.

posterior wall to the inguinal canal. The aponeurosis is now united by a continuous suture (Fig. 455, H), and the skin wound closed. The displacement of the cord, it is said, sometimes causes pain on pressure, and rarely congestion or inflammation, and atrophy of the testis. Many recurrences are stated to have been met with afterwards, but this has not been the experience of one of us (Walsham).

Halsted's modification.—Halsted, of Baltimore, makes an incision parallel to Poupart's ligament from the anterior superior spine of the ilium to the pubic spine. He divides the aponeurosis of the external oblique the whole length of the skin-incision. The sac is then dissected up and sutured by quilted sutures at as high a level as possible and then the lower portion is cut away. The spermatic cord is now transplanted to the outer angle of the wound

in the external oblique and the rent in the aponeurosis sutured in its entire extent beneath the cord. In this way the cord takes a subcutaneous course and a new inguinal canal has been fashioned which passes outwards and upwards from the internal abdominal ring. Halsted has recently modified his method further, and no longer transplants the vas.

A femoral hernia is one that escapes into the femoral sheath, and nearly always internal to the femoral vessels, though in very exceptional cases it has been found external to them. As a rule, it leaves the abdomen at the femoral ring, and after passing downwards through the femoral canal, emerges at the saphenous opening, and then turning upwards and outwards over the falciform process of the fascia lata, passes, should it further increase in size, over Poupart's ligament on to the aponeurosis of the external oblique muscle of the abdomen. The neck of the sac is situated at the *femoral ring* (Fig. 456), and is therefore bounded in front by Poupart's ligament, behind by the bone, internally by the sharp wiry edge of Gimbernat's ligament, and externally by the femoral vein, from which it is only separated by the innermost septum of the femoral sheath. The spermatic cord is close above it; the epigastric artery passes a little external to it; but there is no structure of importance, as a rule, on its inner, and upper and inner side. The obturator artery, however, may be given off from the deep epigastric or external iliac artery, and encircle this part of the ring in its course to the obturator foramen (Fig. 456). It is then in great danger of being wounded in dividing the stricture. Fortunately, however, although the artery often arises in this abnormal manner, it does not then, as a rule, take the above-mentioned dangerous course, but passes along the outer side of the ring, where it is out of danger. The *coverings of a femoral hernia* (Fig. 457) are—1, skin; 2, superficial fascia; 3, cribriform fascia; 4, anterior layer of the femoral sheath, called the *fascia propria;* 5, septum crurale; 6, subperitoneal fat; and 7, peritoneum forming the sac. The fascia propria is often very thin, or in places absorbed, so that little more than skin and one or two delicate layers of fascia cover the sac. But it may be greatly thickened, especially over the neck of the sac, where it may form distinct fibrous bands, which go by the name of the *deep crural arch.* Femoral hernia is never congenital except where there is a hernia of the testis or ovary (*crural ectopia of testis or ovary*); and seldom occurs before adult life. It is more

FIG. 456.—The obturator artery given off abnormally from the epigastric, and running round the upper and inner side of a femoral hernia. (St. Bartholomew's Hospital Museum.)

common in women than in men. The *stricture*, when the hernia is strangulated, is at Gimbernat's ligament at the saphenous opening, or more rarely at the deep crural arch.

Signs.—A femoral hernia appears (Fig. 458) as a tense globular swelling at the upper and inner part of the thigh, just below Poupart's ligament internal to the femoral vessels, and external to the spine of the pubes. It is usually small, but may sometimes be as large as an orange, or even larger. It then extends upwards and outwards over Poupart's ligament towards the iliac spine, and appears as an elongated soft and yielding swelling with its long axis parallel to the ligament. Its neck, however, can always be traced below the ligament towards the femoral ring. The characteristic signs of hernia are, of course, present.

The *diagnosis* has chiefly to be made from enlarged glands, varix of the saphenous vein, inguinal hernia, and psoas abscess. 1. In

Fig. 457.—Femoral hernia. The coverings dissected off to show the sac. (St. Bartholomew's Hospital Museum.)

Fig. 458.—Femoral hernia, with line of incision.

enlarged glands there is no impulse on cough; they can be raised from the deeper tissues, and there will probably be some evident cause, as a sore on the foot, etc., to account for them. A small piece of irreducible omentum, however, may almost exactly resemble an enlarged gland in the femoral canal; and it may be impossible to make a diagnosis without exploring the ring, an operation which should always be undertaken if symptoms of strangulation of the intestine are present. At times there may be an enlarged gland over a hernia. 2. In *varix of the saphenous vein* the vein is generally also varicose lower down the limb, and the impulse on coughing has a peculiar thrill-like character, and extends also some distance down the vein. When the swelling is reduced by placing the patient on her back, and the ring is closed by the finger, the vein refills when she rises, whereas the hernia remains reduced as long as the finger is kept in position. 3. In *inguinal hernia* the neck of the sac is above Poupart's ligament, and inside or over the spine of the pubes; in femoral hernia the neck is below Poupart's

ligament and outside the spine of the pubes. In inguinal, the hernia goes back in a direction upwards, outwards and backwards: in femoral, downwards, and then backwards and upwards. In inguinal, the hernia occupies the inguinal canal, and may descend into the scrotum or labium; in femoral, the inguinal canal is felt free on passing the finger into it. 4. In *psoas abscess* the swelling is generally at first external to the femoral vessels. There is usually fulness in the iliac fossa, and fluctuation can be detected above and below Poupart's ligament. Some cause for the abscess, such as caries of the spine, is generally evident.

Treatment.—All that need be mentioned in addition to what has already been said of the treatment of hernia in general is—1. That the femoral truss (Fig. 435) should have the pad more vertically placed, and the button for the strap should be on the end of the spring and not on the back of the pad, as, if placed in the latter situation, it causes the pad to rise up and so allows the hernia to escape beneath it. 2. That in applying the taxis the leg should be flexed, slightly adducted, and rotated inwards, to relax the falciform process of the fascia lata. 3. That on account of the unyielding nature of the parts there is but little prospect of reducing the hernia under chloroform or by a hot bath. 4. That should the hernia become strangulated, ulceration is rapidly produced, owing to the pressure of the sharp edge of Gimbernat's ligament. Therefore, if the hernia is not returnable by moderate taxis, an operation should immediately be performed. 5. That the incision (Fig. 458) should be made in a vertical direction over the inner side of the neck of the hernia, the skin being nipped up and transfixed to avoid injuring the sac, as the coverings are often very thin. 6. That the stricture should be divided in an upward and inward direction through the junction of Gimbernat's with Hey's ligament. If made directly inwards, the resulting aperture is so large that it is difficult subsequently to keep up the hernia with a truss; while if made directly upwards, the spermatic cord and epigastric artery, and if outwards, the femoral vein, are endangered. 7. Several small notches are preferable to a single and larger incision, as there is less danger of wounding an abnormal artery should one be present. 8. Should such an abnormal artery be wounded it must be tied if possible, enlarging the incision if necessary; otherwise an attempt may be made to twist it or a pressure forceps may be left on.

Cure of femoral hernia.—Make an incision over the hernia from a little above Poupart's ligament vertically downwards about 2½ inches. Having freed the sac, opened it, and returned its contents, clear the neck with the finger passed up the femoral canal. Ligature the neck; cut away the body of the sac, and with the aid of long slightly curved needles carry the two ends of the ligature, which has been tied round the neck, up the femoral canal anterior to the peritoneum and make them emerge through the abdominal wall

just above the round ligament or spermatic cord about a quarter of an inch apart. On tying the two ends of the ligature the sac will be drawn well behind the abdominal parietes. Whilst passing the ligatures protect the femoral vein with the finger, and draw up the skin-incision, that the needles may emerge in the wound. On letting go the skin the knot of the ligature will be covered by it. Some surgeons now draw up the pectineus muscle to Poupart's ligament and sew Hey's ligament to Cooper's ligament (a band of strong ligamentous fibres running along the pectineal ridge of the pubes) by one or two silk sutures, thus closing the femoral canal, but in our experience this procedure is of little value.

Hernia cruralis prevascularis is a hernia which bulges below Poupart's ligament in front of the blood-vessels. It has followed forcible manipulation for the reduction of a congenital dislocation of the hip, probably owing to a rent between the sheath of the vessels and Poupart's ligament.

Umbilical hernia (exomphalos, or omphalocele) is one that escapes at the umbilicus. There are three distinct forms, the congenital, the infantile, and the acquired. 1. The *congenital* is due to an arrest of development, whereby the umbilical ring is imperfectly closed, and a portion of intestine remains outside the abdomen enclosed by the tissues of the cord. This form is rare. 2. The *infantile* is produced by a stretching of the umbilical cicatrix, and usually appears soon after birth as the result of crying, coughing, or straining to pass water, consequent upon a phimosis or narrow meatus. 3. The acquired form, according to Mr. Birkett, consists of a protrusion of the parietal peritoneum through the fibres of the linea alba, near the umbilicus, and seldom appears before middle adult life. It is especially common in stout females who have borne many children. The sac is very thin, frequently cribriform or altogether deficient in places, and may be lobulated, double, or composed of several pouches or sacculi, the result of adhesions between the walls and the contents. It commonly contains omentum, in which large masses of fat have been formed, and part of the transverse colon, and sometimes a knuckle of small intestine, which mostly lies concealed by the omentum at the neck of the sac. The coverings are:—1, the skin; 2, the superficial and deep fascia with a thin layer of fat between them; 3, the fascia transversalis; and 4, the peritoneum, which constitutes the sac.

FIG. 459.—Umbilical hernia, showing the attenuated condition of its covering. (St. Bartholomew's Hospital Museum.)

They frequently, however, become thinned, adherent to one

another, or partially absorbed, so that the contents of the hernia are merely covered with skin and a thin layer of fascia (Fig. 459).

Symptoms.—In infancy, the hernia, which is known by nurses as "starting of the navel," consists of a protrusion at the umbilicus, covered by thin skin, and readily returning when gentle pressure is applied, and when once seen can hardly be mistaken for any other affection. It generally undergoes a spontaneous cure. In adults it forms a globular, lobulated, or sometimes a pendulous or pyriform swelling, on the lower part of which the cicatrix of the navel is seen. It often attains a large size, nearly always extending, as it enlarges, downwards towards the pubes, and is frequently in part or completely irreducible. It is very liable to become obstructed and less often strangulated, and after it has existed some time is nearly always irreducible, owing to adhesion of the omentum or bowel to the wall of the sac. It is often attended by flatulency, dyspepsia, and colic, and by alternate attacks of constipation and diarrhœa.

Treatment.—In infants the hernia generally undergoes a spontaneous cure, and nothing is required beyond drawing the margins of the hernial ring together with a piece of strapping applied transversely over the hernia. Circumcision should be done if the prepuce is long and its orifice narrow. In adults, an umbilical truss or bandage is necessary, or when the hernia is irreducible, a hollow supporting truss. When the hernia is incarcerated, the patient should be placed at rest and an enema administered. When strangulated, an operation must be performed, but the prognosis is very grave. The incision should then be made vertically over the swelling in the middle line, and the sac opened with care, as the coverings are often very thin, and the stricture divided in an upward direction. If omentum presents first, as is usually the case, search must be made for intestine, and the latter returned; the omentum must then be unravelled, freed if adherent to the sac, transfixed with a double ligature, tied, cut off, and the stump also returned. The sac should then be cut off with the redundant skin and the wound sewn up in the way described on page 189. Radical cure is called for when a truss fails to keep back the hernia and obstruction or strangulation is frequently occurring, provided the patient is not inordinately stout or organically diseased, and the hernia so excessive in size that there would probably not be room in the abdomen for the return of its contents.

The *cure of umbilical hernia* may be done by excising completely the sac and the edges of the fibrous ring formed by the linea alba through two semi-circular incisions meeting above and below. The peritoneum, muscles and skin may then be united, layer by layer, by sutures; or if the ring is very large and its margins are dense, a large flange stitch may be used (Fig. 460), as practised by Greig Smith. The cicatricial tissue is divided all round the ring at its

free margin down to the rectus muscle, and the sutures passed first through the upper fibrous edge, then through the rectus, then through the lower fibrous edge on one side of the wound, and then in the reverse order through the tissues on the other side.

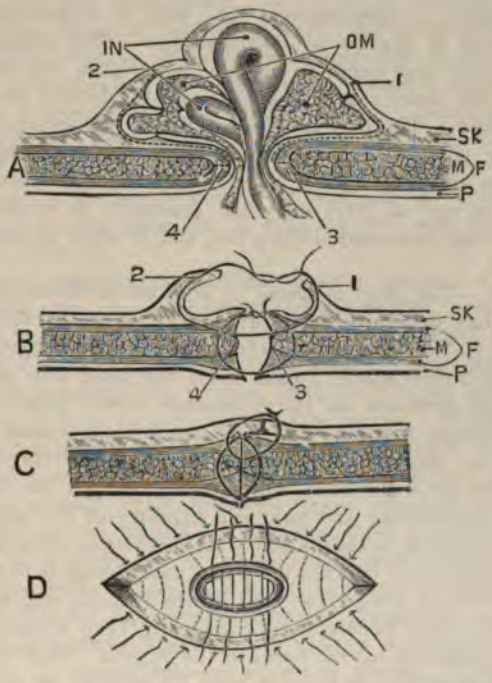


FIG. 460.—Greig Smith's method of performing the radical cure of umbilical hernia. A. Transverse section through hernia and parietes showing sac, contents, ring, and lines of incision. IN. Intestine. OM. Omentum. SK. Skin. F. Fascia, thickened at margin of ring. M. Rectus muscle. P. Peritoneum. 1. Incision through skin of sac, which is continued along the subperitoneal tissue to margin of ring. 2. Same on opposite side. Between 1 and 2, skin and sac are removed on free surface, and sac on deep aspect. 3 and 4. Incisions carried deeply through thickened fascia round umbilical ring to expose recti. B. Gut returned, omentum removed, superfluous skin and sac removed, sutures placed, incisions in fascia opened up and recti exposed. References same as in A. C. Sutures tied, skin suture to one side of parietal line of junction. D. Bird's-eye view showing double set of sutures round umbilical ring and cutaneous wound. (From a drawing by Mr. Greig Smith.)

An obturator hernia is one that escapes through the obturator canal, *i.e.*, the aperture in the obturator membrane for the passage of the obturator nerve and vessels. The neck of the sac is bounded by the horizontal ramus of the pubes above, and by the sharp edge of the obturator membrane elsewhere; whilst the fundus either pushes the obturator externus in front of it, or passes above that muscle or between its fibres and comes into contact with the

pectineus, giving rise to a slight fulness in the upper part of the thigh just below Poupart's ligament, immediately behind and internal to the femoral vessels. The coverings, therefore, are—1, skin; 2, superficial fascia; 3, fascia lata; 4, pectineus; 5, fascia over the obturator externus; 6, obturator externus (sometimes); 7, pelvic fascia; 8, subperitoneal fat; and, 9, peritoneum, forming the sac, which is always an acquired one. The relation of the obturator artery and nerve to the sac is variable, but the nerve is generally to the outer side of the sac, and the artery to the outer side and behind. The hernia is always small, and generally consists of the lower portion of the ileum, often of only a portion of the calibre of the gut. Obturator hernia is rare; it is most often met with after the age of fifty, and then generally in women. It has not always been diagnosed during life, and is often accompanied by other herniæ.

Symptoms.—The chief of these, in addition to those of strangulation, which has generally been present, are a slight fulness below and internal to the femoral vessels, perhaps not perceptible unless the two sides are compared; pain down the inner side of the thigh or knee from pressure on the obturator nerve; pain on pressing over the obturator foramen, and perhaps some increased resistance or swelling in this region; pain on rotating the thigh outwards from the obturator muscles, which are then put on the stretch, pressing on the hernia; and pain and swelling in the region of the obturator membrane on examination by the rectum or vagina. From *femoral hernia* it may be known by the neck being below instead of above the ramus of the pubes; and by the femoral ring being free.

Treatment.—This hernia has occasionally been reduced by taxis, aided in one instance by the hand in the vagina. But this method is dangerous inasmuch as the gut may be injured or may be in a state unfit to return into the abdomen. Also an incision has been made similar to that for femoral hernia, but slightly longer, and after having divided the various coverings and opened the sac, the stricture has been incised in a direction downwards and inwards, avoiding the obturator artery and nerve. But as the diagnosis is always doubtful, the obturator ring should be explored through an incision in the middle line of the abdomen, the hernia, if one is found, being drawn out from the ring from within the abdomen, after the stricture has been cautiously divided. This is rendered easier by raising the pelvis.

Diaphragmatic, or phrenic hernia, is one that protrudes through the diaphragm into the thoracic cavity. It is very rare in this country, but the traumatic form is not uncommon in Italy from stabs aimed at the heart. The aperture may be due to a congenital defect, to the enlargement of one of the natural openings, or to a wound or laceration of the diaphragm including both serous surfaces, such as may be produced by a crush of the chest. The hernia

usually occurs on the left side, the liver tending to prevent any protrusion on the right. As there is no peritoneal sac, the viscus, which is usually the stomach or transverse colon, protrudes into the pleural cavity along with some omentum. In the Museum of St. Bartholomew's there is a unique specimen of a hernia of the omentum into the pericardium, the result of a wound.

Symptoms.—In some cases there have been no symptoms; in other cases unnatural fulness and abnormal resonance of the left side of the chest, with gurgling on auscultation, excessive thirst, and signs of internal strangulation have been observed. When the result of a wound, pleurisy or peritonitis, or both, have generally soon supervened and carried off the patient.

Treatment.—The hernia should be explored by incision into the pleural cavity with resection of ribs, reduced, and the hole in the diaphragm sewn up.

A sciatic, ischiatic or gluteal hernia protrudes through the great sciatic notch above or below the pyriformis. It gives rise to pain down the sciatic nerves, and when strangulated to symptoms of intestinal obstruction. A tense resonant swelling bulges the buttock, obliterating the gluteal fold, and yields an impulse on coughing. It may be reducible or irreducible. Whether strangulated or not it is best treated by abdominal section with the pelvis raised; the gut is cautiously drawn back, examined, and the ring closed from within. The objections to the external operation are—1, the depth of the wound; 2, the danger of wounding the gluteal artery where it is difficult to tie and of injuring the sciatic nerve; 3, the impossibility of drawing down the gut for inspection as to perforation; and 4, the greater difficulty of closing the ring.

A lumbar hernia is practically always secondary either to an injury or to an abscess the scar of which yields. It can usually be controlled by a belt and pad.

Perineal, pudendal, rectal and vaginal herniæ form occasional varieties of prolapse of the pelvic organs, especially of the uterus. The *perineal* hernia in the female is an elongation downwards of Douglas's pouch and protrudes between the vagina and the rectum. In the male a hernia has followed an ectopic testis into the perineum as in the pig. The *pudendal* hernia is an elongation of the lateral vesico-uterine pouch, and protrudes between the vagina and the ascending ramus of the ischium. The *rectal* and *vaginal* hernia protrude respectively into these cavities, pulling down the bladder. These herniæ are usually reducible, and only exceptionally become strangulated. They are all best treated by fixing up the uterus as by Alexander's operation of shortening the round ligaments (*q.v.*).

Ventral hernia is one that occurs in any situation other than those already mentioned, and may be spontaneous or traumatic.

The *spontaneous* form is often an extension of an umbilical hernia

occurring in women who have grown fat after the abdominal wall has been weakened by pregnancy. Another form not always connected with an umbilical hernia is the *boat-shaped protrusion*. This also occurs in women after child-bearing who are not necessarily fat but often quite thin. It is seen when the patient raises herself from the lying to the sitting posture. The linea alba then yields throughout its whole length, whilst the recti are pushed to one side (*divarication of the recti*). A third form is the small ventral epiplocele met with in the linea alba, linea semilunaris, lineæ transversæ, and occasionally elsewhere. It is really a *subperitoneal lipoma* which presses forwards between the tendinous or muscular fibres and becomes subcutaneous. Rarely a small pouch of peritoneum is found in the centre of the fatty tissue, and into this a piece of omentum or even bowel may protrude. It occurs as a small globular, soft, elastic swelling usually in the middle line above the umbilicus, and is often a source of pain. It does not as a rule give a distinct impulse on coughing.

The *traumatic* form may occur in the scar of any wound, but most commonly in the scar of the hypogastric incision or the iliac incision for the removal of the appendix or for evacuation of a perityphlitic abscess.

Treatment.—The spontaneous form may be prevented by wearing a belt during later pregnancies, by not getting up too soon or working too early after labour, by avoiding obesity and constipation, and by wearing an abdominal belt and taking daily walking exercise. A ventral hernia after operation is prevented by carefully suturing the wound either in stages or, if deep interrupted sutures are used, by only taking up the edges of the peritoneum so that the muscle fibres are brought well into contact. The bowels should be kept open, and the patient remain on the back for a month or even longer. Some patients should be given a belt, in others it is unnecessary, but all must avoid undue strain, constipation and food tending to produce flatus. When a ventral hernia has already formed it should be treated by a belt with a pad. If this is insufficient the scar should be excised with the sac and the abdominal walls united in stages. In doing so the recti should be raised from their sheath and united in the middle line. The small ventral epiplocele when consisting merely of fatty tissue should be excised, the pedicle being ligatured and the opening closed by sutures. Before excision care should be taken to exclude a peritoneal pouch. If one is present its neck should be ligatured, any omentum or intestine it may contain being of course first returned.

Diseases of the Umbilicus.

Inflammation followed by *ulceration* or *eczema*, or even by the formation of small *abscesses*, may be met with about the umbilicus.

When chronic and attended with much induration they may be mistaken for malignant disease. If cleanliness and simple ointments fail, the indurated mass may be excised, care being taken not to open the peritoneal cavity.

Condylomata and **mucous tubercles** sometimes occur in this situation in infants the subject of inherited syphilis.

Umbilical fistulæ may discharge urine, fæces, bile or pus.

Urinary fistulæ are the result of a patent urachus, or the reopening of a urachus in an infant in whom the urinary passages are obstructed by phimosis, small meatus, calculus, etc. If the fistula does not close spontaneously when the cause is removed, the urachus should be dissected down to the bladder and the lower end inverted and sutured. It has reopened in later life, even in elderly people, *e.g.*, old men with enlarged prostate.

Fæcal fistulæ may be due to a persistent Meckel's diverticulum, to the bursting of a fæcal abscess the result of tuberculous peritonitis, or to injury of the intestine in a strangulated umbilical hernia. A Meckel's diverticulum, if the intestine below is pervious, is dissected up to the ileum, cut off and the lower end inverted and sutured. The fistula following a strangulated hernia may be dealt with as described at page 912. For fistula resulting from tuberculous peritonitis beyond improving the general health little or nothing can be done. The intestines are matted together, their walls softened, and attempts to close the fistula fail or make matters worse.

Biliary fistulæ are due to an abscess in connection with the gall-bladder or bile-duct making its way along the round ligament to the umbilicus (see *Diseases of the Gall-bladder*).

A *fistula discharging pus* may be the result of suppuration tracking along the abdominal walls from an empyema or from a spinal, peri-typhlitic, or para-metritic abscess.

Tumours of the umbilicus.—*Cystic tumours* may be produced by dilatation of the urachus or of the remains of the umbilical vesicle.

Solid innocent tumours.—Papillomata or polypoid excrescences should be excised; fibromata and other sessile growths are removed with the umbilicus.

Malignant tumours.—Epithelioma and sarcoma rapidly invade the abdominal parietes and extend to the peritoneum and underlying intestine. They should be removed freely, an incision on one side of the growth having been first made through which the finger can be passed beneath it to determine that the intestine is free.

Tumours of the Abdominal Wall.

Phantom tumours.—A peculiar local spasm of the muscles of the abdominal wall may superficially simulate an abdominal tumour, pregnancy, etc. It appears to be due to some reflex influence.

This condition, moreover, may be provoked by any slight irritation, especially in a woman. The phantom tumour, however, is resonant on percussion, and when the patient is anæsthetised a quivering vibration is felt, and the supposed tumour melts away under the hand, though it may return as soon as the patient recovers consciousness.

Lipomata.—Subperitoneal lipomas may protrude between the muscular fibres and should be removed by ligaturing the pedicle without opening the peritoneal cavity.

Gummata and sarcomata arise in the rectus muscle; the former are relieved by antisyphilitic remedies, whereas the latter continue to grow in spite of this treatment, and should then be explored. The whole rectus muscle from the sternum to the pubes has been excised.

Carcinomata.—Epithelioma may occur in the scar of an abdominal wound or in that of a burn.

DISEASES OF THE RECTUM.

An examination of the anus and rectum is carried out by inspection, by palpation of the anus and ischio-rectal fossæ, by digital examination of the anus, which is gently drawn apart. The rectum is examined digitally, also bimanually, the opposite hand pressing on the hypogastrium. A spectrum with a longitudinal slit and an obturator to keep it clear of fæces whilst being passed is sometimes used for inspecting the rectum. Kelly's proctoscope is a metal tube of various lengths, the longer reaching up to the junction with the sigmoid, the patient being in the genupectoral position and the interior of the tube illuminated. A more complete examination is made under an anæsthetic after dilating the anus, in combination with vesical and vaginal exploration (*q.v.*).

Congenital malformations.—Imperforate anus is the only malformation that needs consideration here. *Cause.*—The intestinal canal in early fœtal life ends at some little distance from the surface of the skin, in a blind pouch or cloaca, which is common to it and the genito-urinary organs. In the course of development the cutaneous tissues (epiblast) become invaginated towards the cloaca at the spot which is to be the future anus. The intervening tissues are then gradually absorbed, and a communication is thus established between the cloaca and the surface of the body, the intestinal portion of the cloaca at the same time becoming differentiated from the genito-urinary. An arrest in the above process of development is the cause of imperforate anus. Thus:—1. Should no invagination of the skin occur (Fig. 461), the anus will be entirely absent. In such a case the intestine may terminate in a blind pouch at a variable distance from the surface, a thin membrane or a considerable thickness of tissue intervening between the skin-surface and the interior

of the gut. At times the intestine may stop short of the pelvis, the rectum being then of course wholly absent. 2. Should invagination occur, but the intervening tissues not be absorbed, an anus, to all external appearances natural, will be present, but will be found to terminate in a *cul-de-sac* a short distance from the surface (Fig. 462). Here again either a thin membrane, or a considerable thickness of tissue, may intervene between the top of the *cul-de-sac* and the

Fig. 461.—Anus absent. Rectum terminating in blind pouch. (Rushton Parker.)

Fig. 462.—Anus ending in *cul-de-sac*. Rectum ending in blind pouch, with some but not much tissue between it and *cul-de-sac*. (Rushton Parker.)

Fig. 463.—Anus ending in a *cul-de-sac*. Rectum opening into prostatic urethra. (Rushton Parker.)

interior of the gut (Fig. 462). 3. Should the process by which the intestinal canal is normally cut off from the genito-urinary portion of the cloaca also fail, the intestine, instead of ending in a blind pouch, may communicate with the bladder, prostatic urethra (Fig. 463), or vagina. In rare cases the intestine may open in some other abnormal situation, as the perineum or groin or loin.

Treatment.—Where only a thin membrane intervenes its division is all that is necessary; but when there is no appearance of an anus, or evidently a considerable thickness of tissues between the gut and the surface, a vertical incision should be made in the middle line at

the spot where the anus should be normally situated. If the distended bowel is now seen or felt to bulge in the wound it should be exposed with a few touches of the knife, and then cautiously opened by an incision made in the same direction as the wound. Should it not be thus discovered, the dissection must be carried on cautiously in an upward and backward direction for an inch to an inch and a half, of course keeping to the middle line and well towards the sacrum lest the peritoneum be wounded. If the bowel is detected it should be opened; no attempt, however, should be made to bring it down, but the finger or a bougie passed daily to prevent the wound re-contracting. If not found in this way the colon may be opened in the left groin (*inguinal colotomy*).

Mayo Robson advises us to continue the dissection in the perineum, open the peritoneum, seek the end of the gut, pull it down, and fix it to the skin. The only objection to this method is the extreme smallness of the parts in the new-born infant, an objection that may be partly overcome by excising the coccyx.

Proctitis or inflammation of the rectum is rare. It may be due to injury, gonorrhœa, or dysentery, and run an acute or chronic course. The gonorrhœal form is usually seen in women and may terminate in stricture. It is attended by pain, tenesmus, bloody stools, œdema, and prolapse, and should be *treated* by rest, saline purgatives or castor-oil to empty the rectum, slop diet and hot sitz-baths, and starch and opium enemata to relieve pain. When it has become chronic, astringent injections may be tried.

Pruritus ani, or itching about the anus, though often dependent upon sweat and dirt, constipation, ascarides, pediculi, eczema marginatum, condylomata, piles or other diseases of the rectum, sometimes occurs without any very evident cause, and has then been attributed to disordered digestion and the gouty habit. *Symptoms.*—The itching is often intolerable, and is usually worse soon after the patient gets warm in bed. There may be some slight cracks, a little eczema from the scratching, or a moist and reddened condition of the skin, but occasionally there is nothing to be seen. *Treatment.*—The cause if possible should be removed. Where none is very evident the general health must be attended to, the parts kept scrupulously clean, and an ointment or lotion of perchloride of mercury, black wash, boric acid, nitrate of silver, cocain, or carbolic acid, etc., applied. Lactate of lead, made by pouring lead lotion into milk, often has a very beneficial effect. Carbolic acid 1 in 20 has been injected beneath the skin in several places with success. The affected area may be excised and replaced by an epidermal graft.

Fissure of the anus is a small painful crack or ulcer usually situated just within the anus, and seldom involving more than the skin or mucous membrane. *Causes.*—Almost always constipation, with spasm; sometimes neglect of local cleanliness, or other source

of irritation. The passage of an unusually hard motion is often the immediate exciting cause. When the ulcer is once thoroughly established, healing is prevented by the action of the sphincter and the irritation of its surface during the passage of a motion. Ball attributes it to the tearing of one of the small anal valves situated at the junction of the rectum and anus, and regards the small pile at the distal end of the fissure as an œdematous condition of the torn-down valve. *Symptoms.*—The chief of these is pain, the result of spasm of the sphincter. It is often very severe, and occurs during, and especially after, defæcation. It may last for a few minutes or longer, even to several hours, and then cease till the next motion. The pain may not only be felt in the anus, but may be reflected down the thighs or to other parts, as the uterus, vagina, or testicle. The motions are often slightly streaked with blood, sometimes with pus. On examination the sphincters are found spasmodically contracted. On gently everting the margins of the anus the end of the ulcer will be discovered usually at the posterior part, a small external pile or an œdematous fold of skin which is generally present then serving as a guide to it. The passage of the finger is attended with great pain. *Treatment.*—In slight cases the use of laxatives and the application of astringent lotions or sedative ointments before and after defæcation may be sufficient. If these fail the sphincter may be forcibly dilated, which has the great advantage of tending to relieve the constipation, or the ulcer divided, together with half or more of the external sphincter, by drawing a straight bistoury longitudinally through the base of the ulcer. The bowels should then be kept confined for four or five days, and the motions afterwards kept soft for a fortnight or longer. Or the sphincter may be divided subcutaneously by passing a tenotomy knife beneath it, through the mucous membrane, and cutting outwards towards the skin. Ball treats these cases by cutting off the small pile at the end of the fissure. This little operation and that of subcutaneous division of the sphincter may be done without pain by painting the mucous membrane with cocain or spraying it with chloride of ethyl, and do not necessitate the patient's lying up for more than two or three days.

Prolapsus recti is the protrusion of the mucous membrane of the lower part of the rectum, and more rarely of the muscular coat as well, through the anus. It is most common in children, but may occur at any age. The *causes* are either a relaxed state of the sphincter induced by general weakness, residence in hot climates, etc., or excessive straining due to stricture of the urethra, phimosis, stone in the bladder, ascarides, constipation, piles, or polypus. *Signs and diagnosis.*—It commonly appears as an irregular ring of mucous membrane, or when much is protruded, as a cylindrical elongated swelling. When recent, it has the colour of healthy mucous membrane, but if not soon reduced it may become livid and congested,

in consequence of constriction of the blood-vessels by the sphincter. The strangulation may proceed to such an extent that the prolapsed portion may become gangrenous and slough away. In old-standing cases it becomes indurated and leathery from exposure. It may be diagnosed from polypus by the presence of a central aperture, and from intussusception by the mucous membrane being continuous with that of the sphincter. In intussusception a sulcus exists between the protruded part of the bowel and the sphincter.

Treatment.—Should the bowel be protruded or strangulated, an attempt should be made to reduce it. If it has been prolapsed only a short time, this is easily accomplished by gentle pressure, the parts having been well smeared with vaseline and the buttocks raised. When of longer standing, firm pressure must be exercised on it for ten minutes or so, or the finger may be introduced into the orifice and the bowel pressed back. If reduction fails and the part is much inflamed, an ice-bag may be applied, and another attempt subsequently made, when, if still unsuccessful, nothing remains but to allow the protruded part to slough off or to excise it. If the muscular coat protrudes, no operation should be done lest the peritoneum be wounded. Having reduced the bowel, the cause of the prolapse should, if possible, be removed, and to prevent a recurrence the nates may be strapped together, or a pad and T-bandage worn, and the motions passed at bed-time instead of in the morning, the patient lying on his side or back during defæcation. Astringent lotions, or ointments of sulphate of iron, galls or tannin should be applied, or the mucous membrane painted with nitrate of silver, whilst any pendulous folds of skin may be snipped off, so as to cause some amount of contraction of the anus. In the meanwhile, the motions should be rendered soft with gentle laxatives. Should these means, after being well persevered in, fail, a more serious operation may become necessary. Thus, portions of the mucous membrane may be removed by ligature, as in the case of piles; or the galvano-cautery may be applied in two or three situations, so as to produce lines of burns in the long axis of the bowel, and thus cause the mucous membrane to adhere to the muscular coat by inflammation.

When the prolapse becomes very extensive, either it must be excised as directed for carcinoma, or the gut must be drawn up and fixed to the inner surface of the abdominal wall through a hypogastric incision.

Hæmorrhoids or piles are swellings inside or around the margin of the anus, the result of a dilated or varicose state of the blood-vessels.

Causes.—The peculiar anatomical arrangement of the hæmorrhoidal veins, in that they pierce the muscular coat of the rectum, and hence are liable to be constricted during straining as in chronic

constipation; the absence of valves in them and in the veins through which they communicate with the portal vein, whereby they have to sustain the whole weight of the column of portal blood; and their situation between the muscular and mucous coats of the rectum, so that they receive but little support during defæcation, render them exceedingly liable to become dilated or varicose. Anything, therefore, that tends to congest the portal system, and hence obstruct the return of venous blood from the hæmorrhoidal veins, such as high living, cirrhosis of the liver, heart-disease, etc., may be looked upon as a predisposing cause; whilst anything determining local congestion of the part, such as habitual constipation, straining at stool or to pass water in cases of enlarged prostate or stricture of the urethra; the pressure of the gravid uterus, distended colon, or ovarian or other pelvic tumour; stricture of the rectum; and the abuse of aloetic purgatives, may be regarded as an exciting cause.

Pathology.—Hæmorrhoids consist at first of little more than dilated veins, but after they have existed some time the blood in their interior may clot, the vein-walls hypertrophy, and the connective tissue of the dilated vein become infiltrated and thickened. If a pile is now cut into, it presents a spongy vascular structure, with a small artery in its centre. Piles may be situated external to the sphincter, and are then covered with skin (*external or blind piles*); or within the sphincter, when they are covered with mucous membrane (*internal or bleeding piles*). In many instances, however, they are covered in part with skin, and in part with mucous membrane (*mixed piles*). An œdematous and swollen condition of the muco-cutaneous folds and hypertrophied flaps of skin about the margin of the anus, although not produced by dilatation of the veins, is also generally spoken of as piles. *External piles* occur as soft, globular, pinkish-blue swellings, or as moderately firm fleshy tumours, or as little more than loose hypertrophied folds of skin. *Internal piles* also present various forms. They may consist of small hæmorrhoidal veins, dilated and varicose, giving the mucous membrane a dark purplish colour, and rendering it liable to become prolapsed during defæcation; or they may form either slightly raised, flattish and oblong elevations, or distinctly globular pedunculated swellings (Fig. 464). They may appear very vascular from the congestion of the mucous membrane covering them, and then constitute the bleeding pile; or they may be firm and fleshy and of a reddish-brown colour from the thickening of the mucous membrane, and then do not

Fig. 464. — Internal piles. (St. Bartholomew's Hospital Museum.)

readily bleed. The hæmorrhage is usually arterial, and comes from the small arteries in the mucous membrane. Piles, whether external or internal, are at times liable to become inflamed and slough.

Symptoms—External piles, beyond causing some amount of itching and unpleasant sensations about the anus, may give rise to no symptoms unless irritated or inflamed. They are then often a source of much distress. The pile becomes swollen and painful, the pain being reflected to the surrounding parts, and increased on sitting, standing, and walking. The acute symptoms usually subside in a few days, but often leave the parts thickened and irritable, and are liable to recur from time to time. *Internal piles* are productive of more trouble, the chief symptoms to which they give rise being hæmorrhage, and irritation and pain consequent on their protrusion and constriction by the sphincter or as a result of their becoming inflamed; whilst the hæmorrhage, when severe, may be productive of anæmia and all its attendant constitutional symptoms. The amount of hæmorrhage may vary from a few drops—a mere streaking of the motions with blood—to several ounces.

When first noticed, the protrusion of the piles occurs only during defæcation; and although they may at first go back spontaneously, they often require replacement by the finger, as otherwise they are apt to become strangulated by the sphincter and irritated or inflamed from the chafing of the clothes. Later the sphincter becomes dilated, and they may protrude at times other than during defæcation, and in long-standing cases the mucous membrane becomes permanently prolapsed, and the pile remains constantly protruded. External piles then generally form in addition to the internal, whilst the mucus exuded from the parts is a constant source of annoyance. The constitutional symptoms to which the loss of blood and the pain and irritation may give rise are pallor, palpitation, breathlessness, fainting, and headache. From the reflex character of the pain the patient may refer the symptoms to other parts, as the testicle, bladder, kidneys, spine, or uterus.

Diagnosis.—External piles may be readily diagnosed from condylomata, polypi, and carcinoma by the characters already given. *Internal piles* may be suspected from the above-mentioned symptoms, and if not protruded they may generally be brought into view by asking the patient to bear down as if to defæcate, whilst the surgeon makes gentle traction on the margin of the anus. If this does not succeed and the bowel is loaded, an enema should first be given. Examination with the finger, unless the surgeon has had some experience, fails to detect the pile, as when neither irritated, inflamed, nor protruded it is soft and flaccid, like the rest of the mucous membrane.

The *treatment* of piles may be divided into the palliative and the radical.

The *palliative* treatment consists in employing such means as are calculated to relieve the congestion of the hæmorrhoidal veins. Thus constipation must be combated by the use of such laxatives as the confection of senna, compound liquorice powder, the liquid extract or cordial of cascara sagrada, or Apenta or Friedrichshall waters; whilst strong purgatives especially aloes, high living, and alcoholic stimulants should be avoided and the secretions of the liver promoted by exercise. Where there is hæmorrhage, the tincture of hamamelis or of steel will be found very useful. Locally, the parts should be kept scrupulously clean, and astringed by such applications as the liquid extract of hamamelis, the compound ointment of galls, the ointment of calomel, or ointments or lotions of sulphate of iron, acetate of lead, or tannic acid, passed through the sphincter by Ryall's ointment introducer (Fig. 465); or by injections of ice-cold water, to which tincture of hamamelis may be added. When the piles are inflamed, the patient should rest in bed with the buttocks raised, an ice-bag or hot boric acid poultice should be applied, and

Fig. 465.—Canny-Ryall's ointment introducer.

a morphia suppository introduced into the rectum. Where coagulation has taken place, free incision into the pile and turning out the clots will give relief.

The *radical* treatment consists in removing the piles, but should be resorted to only when palliative measures after a fair trial have failed, or when the piles are more or less constantly down. It need hardly be said that no operation should be performed when they are merely symptomatic of some more serious disease, as stricture or cancer of the rectum, enlargement of the prostate, or disease of the uterus, bladder, or liver, or are the result of pregnancy. The method of removing the piles differs according as they are external or internal.

External piles may be simply snipped off with the scissors, care being taken, however, not to remove too much of the integument lest troublesome contraction of the anal orifice should ensue.

Internal piles may be treated by ligature, the clamp and cautery, crushing, injections with carbolic acid, excision, or the application of nitric acid. Whatever method is employed a purgative should

be given the day before, and the rectum cleared on the morning of the operation by an enema; and after the patient is under the influence of the anæsthetic, the anus should be forcibly dilated with the fingers or thumbs (Fig. 466), the muscular fibres being stretched, *not* ruptured, to bring the parts well into view, and to paralyse the sphincter.

If the *ligature* is employed, the most prominent pile should be seized with the pile-forceps or pile-hook, and the mucous membrane incised with the pile-scissors at its junction with the skin, so as to detach the pile and mucous membrane from the anal margin. A stout silk ligature should then be placed in the groove thus formed, and tied tightly around the undetached base of the pile, taking care to include as much of the mucous membrane above the pile as possible. The greater part of the pile having been excised, the ends of the ligature are cut off and the stump of the pile returned after the others have been treated in a similar way. The ligature should be

Fig. 466.—Forcible dilatation of the sphincters. (Esmarch and Kowalzig.)

tied as tightly as possible, and care taken to leave an abundant frill of the pile beyond the ligature to prevent slipping. The parts should be thoroughly dusted with iodoform, a morphia suppository passed into the anus, and a large pad of iodoform wool applied and secured *in situ* by a T-bandage. Some surgeons insert a rubber tube to allow flatus to escape, others insert a plug of gauze, but we have found such measures unnecessary, and to cause considerable irritation and annoyance. The bowels should be kept confined for four days by small doses of opium combined with tincture of catechu, and then opened by castor-oil or an enema of olive-oil. Should retention of urine occur, as is very common after operations on the rectum, it should be relieved by passing a soft catheter. The ligatures generally come away about the ninth to the eleventh day.

Clamp and cautery.—A pile having been seized with the forceps, the clamp is applied to its base, the pile shaved off, and the raw surface cauterised. As the eschar is easily rubbed off all the piles should first be clamped.

If *crushing* is employed, the pile is drawn into the crusher, which

is then screwed tightly home, the pile cut off, and the crusher removed after a minute or two.

Excision has of late been extensively employed by some surgeons. It consists in dissecting away the piles, tying any arteries that bleed, and bringing down the mucous membrane and securing it by suture to the anal margin. It is a needlessly severe operation.

Injections of carbolic acid.—The strength usually employed is half a drachm of the acid to a drachm each of glycerine and water, four or five minims being thrown into the centre of the pile by a hypodermic syringe. The process has to be repeated several times, takes some weeks to effect a cure, and is not without danger of embolism.

Nitric acid is a useful and efficient application for the sessile vascular pile, and should be applied under cocain, with a glass rod through a speculum, and any excess of acid removed by a weak alkaline lotion.

An ischio-rectal abscess (Fig. 467) is one that forms in the loose cellular tissue in the ischio-rectal fossa, and should be distinguished, on the one hand, from the small abscesses which may

Fig. 467.—Ischio-rectal abscess. Fig. 468.—Complete fistula. Fig. 469.—Blind internal fistula. Fig. 470.—Blind external fistula.

occur round the margin of the anus in the cutaneous folds (*perianal*), and, on the other hand, from the abscesses which may form between the mucous and muscular coats of the rectum or round the gut in the pelvic cellular tissue. The *cause* of ischio-rectal abscess is inflammation around the rectum (*periproctitis*). The inflammation may be due to perforation of the mucous membrane by a fish-bone or other foreign body, followed by ulceration and the escape of fæces into the ischio-rectal fossa; or it may be due to injury from without, as a kick or blow. In tuberculous subjects abscess is common from very slight causes, and is probably then the result of the breaking down of a local deposit of tubercle. The *symptoms* vary according as the abscess is acute or chronic. The acute begins with pain, which soon becomes throbbing, and is followed by swelling and redness on one side of the anus, and later by fluctuation. In the chronic the symptoms may be so slight as to escape notice till the abscess bursts into the bowel and the pus escapes by the anus. *Treatment.*—An early incision should be made in order to prevent, if possible, the abscess breaking into the bowel and a fistula resulting. The incision should be free and of a T-shape, to secure a free vent for the discharge and promote the healing of

the abscess from the bottom, lest the abscess-cavity, as is very frequently the case, from the constant action of the sphincter, degenerate into a fistula. (Figs. 468, 469, 470).

Fistula in ano is a fistulous track by the side of the anus. Three forms are described:—1. The *complete* (Fig. 468), in which the fistula opens internally into the rectum, and externally on to the skin; 2. The *blind external* (Fig. 470), in which it only opens on to the skin; and 3. The *blind internal* (Fig. 469), in which it only opens into the bowel.

The *complete* (Fig. 468) is by far the most common form. It generally extends obliquely upwards on one side of the anus and opens into the bowel posteriorly between the external and internal sphincters, or it may take a curved course around the bowel and then open into it (*the horseshoe fistula*). Frequently it extends up beyond the internal opening by the side of the rectum in the form of a *cul-de-sac*; or it may, though very rarely, open into the bowel several inches above the anus. In rare instances there may be two internal openings. Secondary fistulæ branching off from the main fistula are often found burrowing beneath the skin of the perineum and buttock, and sometimes opening at a considerable distance from the anus. The external opening, however, is usually about half an inch from the anus; but it may be a greater distance from it, or close to it, and then, perhaps, hidden by the loose folds of skin. It may be little more than a minute hole exuding a slight moisture; or it may be encircled by a ring of granulations, and the skin in its neighbourhood may be red and brawny. The fistulous track itself will generally be found lined with a smooth shining membrane, and its walls indurated when it has existed some time.

Causes.—A fistula is generally the result either of the bursting of an ischio-rectal abscess into the bowel, or on to the skin, or in both directions; or of ulceration or perforation of the mucous membrane and the extension of the ulcerative track downwards towards the skin, which it may or may not penetrate. It is often seen in phthisical subjects, and occurs as a complication of cancerous and other strictures of the rectum. The two chief reasons why the fistula does not close are the constant movements of the sphincter and the escape of fæcal matter into it.

Symptoms.—Uneasiness, pain or tenderness of the parts, especially on defæcation and movement; more or less constant discharge of pus or purulent fluid from the external opening; escape of fæces where the fistula is complete, or a slight discharge of pus from the bowel with the motions if the fistula is of the blind internal variety; mental worry, anxiety and depression; at times exacerbation of the inflammation with pain and increased discharge; and probably the history of a previous abscess having formed in the ischio-rectal fossa.

Diagnosis.—In the *complete variety* (Fig. 468) the diagnosis is

readily made by passing a probe up the fistula into the bowel, and by feeling the internal opening (which has sometimes the form of a small depression in the centre of a slight papilla-like eminence) with the finger in the rectum. In the *blind internal* (Fig. 469) a soft spot in the centre of an indurated portion of the tissues by the side of the anus will be felt, and probably an indurated track will be detected leading from this towards the bowel. The internal opening, which has the characters given above, will be discovered just within the anus on passing the finger into the rectum. Into this opening a bent probe may be passed, and its end made to project under the soft spot on the skin-surface. In the *blind external* (Fig. 470) the probe cannot be made to enter the bowel on being passed up the fistula, and no internal opening can be felt in the rectum by the finger. In all cases the rectum should be carefully examined to exclude stricture or cancerous disease. From urinary fistulæ tracking down towards the anus a fistula in ano is readily distinguished by the characters given above, and by the absence of urethral and bladder trouble, and by no urine escaping through the fistula.

Treatment.—Although in exceptional instances fistulæ have closed spontaneously, an operation, as a rule, is required. Before operating for fistula the chest ought always to be examined, since, should tubercle in the lungs be discovered, no operation should be done unless the tubercle is in an early stage. The urine should also be tested for albumen, and the absence of stricture or cancer of the rectum determined. *Operation.*—A director should be passed through the fistula into the bowel, and its point hooked down and brought out at the anus by the index finger, which has been passed up the rectum. The bridge of tissue, which sometimes includes the external sphincter, is then divided by running a curved bistoury along the director. The upward prolongation of the fistula beyond the internal opening (Fig. 468) should next be laid completely open into the cavity of the bowel. A careful search should now be made with a probe for all secondary fistulæ or lateral sinuses, and these laid freely open. The lining membrane of the fistula should next be destroyed by excising it with a bistoury, or scraping it with a Volkmann's spoon, as otherwise the fistula is apt to re-form. The wound should finally be filled with iodoform wool, and a pad and T-bandage applied. When there have been secondary fistulæ extending widely into the surrounding tissue, Walsham has succeeded in greatly lessening the time of healing by cutting completely away the lining membrane of the outlying portions and bringing the raw surfaces together by suture.

After the operation the bowels should be kept confined for about four or five days with small doses of opium, and then relieved by castor-oil or an enema. The wound should be dressed daily with iodoform wool lightly pressed into it to insure its healing from the

bottom. When the internal opening is very high up a stout ligature may be passed and made to cut its way out, the fistula healing behind it. But as this takes a long time, it is better to reduce the fistula in this way to reasonable limits and then divide it. The *blind external* and the *blind internal* should, as a rule, be converted into complete fistulæ by forcing, in the former case a director up the fistula into the bowel, and in the latter by cutting through the skin on the point of a bent probe hooked into the internal opening, and made to project under the skin. Both are then treated as a complete fistula. In some cases of blind external fistulæ a free T-shaped incision will suffice without cutting through the sphincter or entering the rectum.

Polypi generally occur as pedunculated growths springing from the submucous tissue, usually of the lower part of the rectum. They vary in size from a pea to a cherry, and in colour from white or pale pink to a deep red. The two chief forms are (1) the *soft or vascular*, which show microscopically an adenomatous structure with at times some amount of myxomatous degeneration, and are most

Fig. 471.—A curved pointed bistoury.

common in children; and (2) the *hard or fibrous*, which are more rare and generally occur in adults.

Symptoms.—Polypi are the commonest cause of bleeding from the rectum in children, the blood escaping not only during but also after defæcation. When low down they cause straining, perhaps a mucous discharge, and agonizing pain after defæcation from being caught in the sphincter. When large they may produce prolapse or intussusception. Small polypi beyond the reach of the sphincter may cause no symptoms. They are usually detected by sweeping the finger well round the rectum, the examination being best made after the bowels have been emptied and the polypus brought down by an enema.

The *treatment* consists in ligature of the pedicle, followed by excision of the growth. They do not recur.

Papillomatous or villous tumours of the rectum are rare. They have a papillomatous structure, spring from the mucous membrane, and may be single or multiple. The *single papilloma* (Fig. 472) occurs as a distinct flocculent villous growth giving rise to great irritability of the rectum and frequent hæmorrhages. They are most frequently met with in patients over forty years of age. The *multiple* occur as small growths having similar characters to the single, and may be scattered in great numbers throughout the rectum and over the lower part of the colon. They occur in young

adult males, and are often met with in several members of the same family, and frequently terminate in carcinoma. Frequent hæmorrhages, diarrhœa, irritability of the bowel and the passage of a glairy mucous discharge are the chief signs. *Treatment.*—The single variety and the larger tumours in the multiple form should be removed with as many of the smaller as can be got away. They are apt to recur and then to become malignant.

Epithelioma of the anus is occasionally met with at the junction of the skin and mucous membrane. It occurs in old people as a nodular indurated mass, having the ordinary characters of an epithelioma. The inguinal glands become enlarged, but dissemination in internal organs is late. It must be distinguished from

Fig. 472.—Papilloma of the rectum. (St. Bartholomew's Hospital Museum, No. 2,063 *a*.)

a syphilitic sore. *Treatment.*—Free excision along with the inguinal glands.

Stricture of the rectum may be divided into the simple and the malignant.

1. **The simple or fibrous** stricture may be caused by the fibroid contraction of inflammatory products in the mucous and submucous coats, or of cicatrices following simple, syphilitic, or dysenteric ulceration; by injury, or operation on the bowel; or it may be the result of pelvic inflammations (*peri- or para-metritis*).

Pathology.—The stricture is generally situated from one to two inches from the anus, but may occur at any part. It may involve only a narrow ring-like portion, when it is called annular; or it may include an inch or more of the gut, when it is sometimes spoken of as tubular. The strictured portion of the bowel consists in great part of fibrous tissue. The *syphilitic* variety, which is much more

common in women than in men, is often combined with condylomata or ulceration about the anus, and the mucous membrane between the anus and the stricture is frequently ulcerated. The *simple annular* form met with in women is believed by some surgeons to be due to gonorrhœa or to pelvic inflammation. It generally occurs about an inch within the anus, the mucous membrane below showing no evidence of previous ulceration.

The bowel above the stricture, whatever the variety, is generally distended with fæces, the muscular coat hypertrophied, and the mucous membrane ulcerated; whilst, in the neighbourhood of the stricture, the coats are often so thin that the least force causes them to give way. Fistulæ often form below the stricture, and hæmorrhoids are a frequent concomitant.

Symptoms and diagnosis.—Pain and difficulty in passing a motion, constipation, and later, constipation alternating with diarrhœa. The motions, when the stricture is near the anus, become small, ribbon-like, and streaked with discharge. There is a frequent desire to defæcate, but little passes except wind and discharge, and the bowel feels as if it had not been emptied. In tight strictures or in strictures with ulceration, fistulæ may sometimes form about the anus, and the patient gets worn out, and, after many years perhaps of suffering, may die of an attack of peritonitis or obstruction. The stricture is readily detected on passing the finger, but is often so tight that only the tip can be got into it. When this is the case on no account should the finger be passed through it, as the slight force of passing the finger may rupture the attenuated walls and peritonitis and death may follow.

Treatment.—As a rule, gradual and careful dilatation by means of bougies, of which the soft flexible ones of Mr. Goodsall are perhaps the best, should be first attempted, and will generally be successful; but the stricture must be kept dilated by the subsequent occasional passage of a bougie. In exceptional cases, where the stricture is very resistant, a bougie may be tied in for some hours at a time. Where the parts are much riddled by fistulæ a division of the stricture may be necessary. This may be done by what is called internal or external *linear proctotomy*. In the former operation the knife, guided by the finger, is introduced through the stricture, which is then divided in a posterior direction; in the latter, the stricture, together with the external sphincter and other intervening soft parts, is completely divided down to the coccyx. The wound is then stuffed with iodoform gauze and bougies subsequently passed daily to prevent recontraction. In very obstinate cases excision is done and the healthy bowel above brought down and fixed to the skin.

2. **Malignant or cancerous stricture.**—*Pathology.*—Cancer may affect the anus, and then as in other situations where it occurs at the junction of skin and mucous membrane, takes the form of squamous-celled carcinoma (see *Epithelioma of the Anus*, p. 947).

When cancer arises within the rectum it is nearly always of the columnar or adenoid variety (Fig. 473). It generally occurs after middle life, but may be seen in young adults, even under twenty. It then occurs either as a fungating, more or less distinct tumour projecting into the lumen of the bowel, or as a laminar, nodular, or ring-like infiltration of its coats. In either case, it is at first covered by apparently unaltered mucous membrane, which, however, is sooner or later destroyed by ulceration, leaving an ulcer with an uneven, proliferating, or excavated surface, everted edges and an indurated base. As the disease extends it involves the muscular coat, and subsequently the surrounding structures and organs, gluing

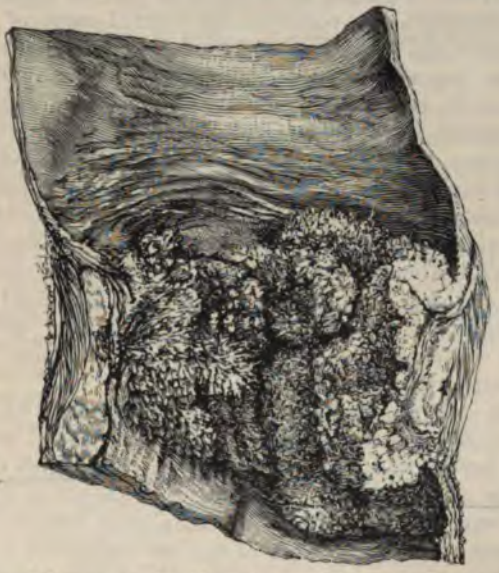


FIG. 473.—Columnar or adenoid carcinoma of the rectum from a man aged 64 years. (St. Bartholomew's Hospital Museum, No. 2069 *a*.)

them, as it were, to the rectum, and finally converting the whole into a cancerous mass. The lymphatic glands in the concavity of the sacrum, and later the lumbar glands, become affected, and the carcinoma may finally be disseminated, secondary growths being more especially met with in the liver. The *symptoms* are often very insidious. At first there may be merely some complaint of indigestion or flatulency, but nothing referable to the rectum; later there may be uneasiness, hardly amounting to pain, about the anus; then more or less backache and pain on defæcation is noticed; the fæces may be streaked with mucus or with blood; and a slimy discharge may be present. Later the motions become small, flattened, or pipe-like when the stricture is near the anus, or scybalous when some distance

above. The patient strains at stool, and feels as if his bowel had not been emptied; then there is constipation alternating with diarrhœa, and an offensive sanious discharge. If low down multiple fistulæ may form, if high up extension may take place to the bladder, or the ureters may be compressed. The glandular enlargement by pressing on nerves causes great pain down the legs. Emaciation and cachexia now come on, with more local pain, and the patient dies of exhaustion, peritonitis, or during an attack of acute obstruction.

The *diagnosis* can only be arrived at by a local examination. The anus generally appears healthy, though probably patulous, and a healthy strip of mucous membrane usually exists between the anus and the growth. When the growth can be felt, its indurated base, and when ulceration has occurred, the everted edges of the ulcer, and the sanious and foul discharge, render the diagnosis generally easy. When beyond the reach of the finger it may at times be brought down by asking the patient to strain. The fungating form may be mistaken for a villous growth; the annular, for a simple fibrous stricture. A *villous growth* may be distinguished by its velvety and supple feel, by its not ulcerating and breaking down, by the absence of induration, by the discharge being thin and mucoid, the blood bright and small in quantity, and the rectum not fixed, and by the duration of the disease. A *fibrous stricture* may be known by its long duration, by being less indurated than the cancerous form, by the bowel not being fixed, and when due to syphilis, by the absence of a healthy strip of mucous membrane between the growth and the anus.

Treatment.—If the disease is seen sufficiently early and before it has involved the surrounding parts, and if the general condition of the patient is otherwise favourable, excision of the growth with the lower end or even the whole of the rectum should be undertaken, as in this way the cancer may be completely removed, and not without reasonable hope, in some of the less malignant forms of the disease, of its not returning. Some cases have been reported where it has not done so for several years. Before forty the disease is so malignant that removal is all but hopeless. In older patients the results are relatively favourable. Previous to removal of the rectum, many invariably perform inguinal colotomy, since after this operation there is less risk of the wound left by the excision becoming septic. Where removal seems impracticable, or otherwise unadvisable, such palliative measures should be adopted as may render the last few months or years of the patient's life as comfortable as possible. Thus the bowels should be kept gently relaxed, the diet regulated, and the pain relieved by morphia suppositories. In this way the patient can often follow his occupation in comparative comfort and with little inconvenience. Should, however, there be very frequent calls to defæcate, much pain and irritation on the passage of fæces, or obstruction threatened or have already occurred, colotomy should

be performed (p. 866). This operation should not, as is too frequently the case, be regarded merely as a last resource, to be undertaken when obstruction has come on, as then the danger of the operation is greatly increased. Nor should it be undertaken in every instance, since the inconvenience caused by the cancer is not always sufficient to justify the patient undergoing the risk. There is no sufficient evidence that colotomy retards the malignant growth, and one symptom is not relieved by it, viz., pain caused by pressure on pelvic nerves.

Excision of the rectum may be performed if the growth is moveable; if the urethra, prostate, vagina and bladder are not involved; if the glands are not enlarged, and if the patient is otherwise fairly healthy. The removal may be done by the perineum in the male, by the vagina, or better by the coccygeal or sacral routes.

THE PERINEAL ROUTE.—The patient having been placed in the lithotomy position and a staff introduced into the bladder, a curved bistoury should be passed along the finger up the rectum, and its point made to emerge near the coccyx, and the intervening tissues cut through in the middle line. By this incision a free exposure is obtained. Lateral incisions are next made on each side of the anus, meeting in front, the levatores ani divided, and the bowel rapidly cleared either with the finger or with the handle of the scalpel from the tissues of the ischio-rectal fossa. The lower part of the rectum is now dissected more carefully from the urethra and prostate, and when it has been sufficiently freed, cut off with scissors, the vessels being clamped as they are cut and afterwards tied. When the growth does not involve the whole of the bowel, a strip of mucous membrane should, if practicable, be left. The rectum should now, if possible, be drawn down and sutured to the skin by four deep sutures passed under the divided pelvic structures. The gut should be plugged with iodoform gauze for a week, a tube being placed through the gauze to allow of the escape of flatus.

THE VAGINAL ROUTE.—A longitudinal incision is made through the posterior wall of the vagina, the rectum excised, and the vaginal wound then united.

COCCYGEAL AND SACRAL ROUTES (*Kocher's and Kraske's operations*).—The greater part or even the whole rectum may be excised by these methods when the disease is fairly moveable. Their special merits, besides giving room, are that the presacral glands can be removed up to the promontory and bleeding is well under control. The patient is placed in the prone position with the pelvis well raised by a bolster. By arranging pillows the head can be turned to one side and the anæsthetic easily given. Alternatively the patient may be in the left lateral position on a fairly high table. An incision is made from the anus to the middle of the sacrum, and the coccyx having been freed from its muscles and ligaments is then cut away (*Kocher's operation*, Fig. 474). The two lower segments,

not more, of the sacrum may also be removed if necessary (*Kraske's and Bardenheuer's operation*, Fig. 474, *a* and *a a'*). There is no advantage in trying to preserve these bones since necrosis may follow their replacement. The presacral tissues are now separated from the sacrum well above the growth, or up to the promontory, and the sides and front of the rectum are separated by the finger or by a blunt dissector. If, as is often the case, the peritoneum is not involved, it may be carefully stripped off by the finger or by a sponge on a holder. If it is involved the cavity is opened freely and the gut drawn down. One of the simplest ways of dealing with the gut, if a preliminary colotomy has not been performed, is to pass a Paul's tube well beyond the growth and tie it in with a ligature round the neck and then excise the growth. The glass

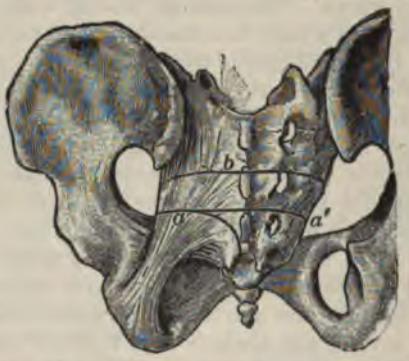


FIG. 474.—*a*. Incision, through the sacrum, of Kraske. *a a'*. Incision of Bardenheuer, who takes away the whole lower part of the bone as far as the third sacral foramina. *b*. Incision of Volkmann and Rose, which passes through the bone, at an unnecessarily and dangerously high level. (Esmarch and Kowalzig.)

tube allows fæces and mucus to pass into a urine bottle for some days before it cuts its way out. If a preliminary colotomy has been performed, and the gut comes down freely, the stump, after the growth is excised, may be drawn through the intact sphincter, the mucous membrane of the latter having been cut away; or, if it will not come down, it may be fixed into the posterior end of the wound, the rest of the wound being partly sutured and partly filled with iodoform gauze, which is frequently changed. Or the upper end of the bowel, after the growth has been cut away and the vessels tied, may be joined to a healthy anal portion, if such can be left; but this is likely to lead to a very tight stricture at the point of union, and bougies will have to be used to keep it dilated. If the sphincter is preserved the patient may regain control. If the gut has to be fixed in the posterior end of the wound he has to wear a special truss with a plug. In some cases the gut has been passed

through the gluteus maximus, the fibres of which act as a sphincter. The peritoneum when opened should be closed by suture. The bladder or vagina may be injured when the growth involves them, also the ureter has been wounded. If these accidents occur sutures should be applied at once, but operations involving such risks should not be undertaken. In all cases of a doubtful and extensive nature a preliminary inguinal colotomy is an advantage. Excision of the rectum is then done three weeks later, the bowel being previously rendered aseptic by irrigating it through the colotomy opening. But the patient is left with two openings, one discharging fæces the other mucus, or he must undergo a further operation for closure of the colotomy opening.

DISEASES OF THE URINARY ORGANS.

SURGICAL DISEASES OF THE KIDNEYS.

Examination of the kidney and ureters.—1. On *palpation* the normal kidney cannot usually be felt; even in thin patients under an anæsthetic the outline is by no means exactly to be made out. It can be felt, however, though of normal size, if it is moveable, whether floating in the abdomen or slipping down behind the peritoneum. When enlarged it tends to fill and bulge the loin, has the peculiar shape of the organ, and does not move with respiration unless very large.

2. *Percussion.*—A kidney tumour should be resonant on light percussion owing to the colon being in front of it, and this is the more marked when the colon is distended by inflating it through the rectum. On deep percussion it is dull.

3. *Pain.*—When moderately firm pressure over the kidney causes pain or a sickening sensation some diseased condition is probably present. Pain may be felt in the loin, down the course of the ureter, in the groin in the region of the appendix or ovary, or in the testicle, which may be tender or drawn up by the cremaster. It has not been proved that pain can be transmitted or reflected to the opposite side (Morris), and such cases, viz., of obvious disease on one side and pain on the other, probably indicate bilateral disease.

4. *Examination of the urine* is essential in the diagnosis of affection of the kidney. The facts that should be noted are the total quantity passed per diem, the average amount of urea that it contains, its reaction and specific gravity, and whether abnormal substances are present as albumen, sugar, pus, blood or special crystals (see p. 970).

5. *Examination by the rectum or vagina* may detect a stone lodged in the lower end of the ureter or a thickening of the ureter.

6. *Examination with the cystoscope* may be employed, and by it a jet of blood, or even pus, may be perceived spurting out of the

orifice of the ureter into the clear water with which the bladder has been filled.

7. *Catheterisation of the ureters.*—The ureters have been catheterised, in the male under the guidance of the cystoscope, in the female through a urethral speculum, the patient being in the lithotomy position with the buttocks well raised, or in the genu-pectoral position. Catheterisation of the ureters is, however, not free from danger as tending to aid septic materials to ascend the ureter to the kidney, and also as causing reflex suppression of urine. Moreover, it is easy to make the ureter bleed, and this may introduce a fallacy.

8. *Examination by the x rays.*—A calculus in the kidney may be discovered in this way (see Plate XVIII.).

9. *Examination through an abdominal incision.*—A shrunken or dilated kidney, a horse-shoe kidney, and a stone in the pelvis or ureter not perceptible through the abdominal wall may sometimes be detected in this way. It is possible, however, even when the hand is in the abdominal cavity, to miss such conditions on account of excess of renal fat or inflammatory thickenings. An abdominal exploration, moreover, does not solve the question whether a kidney of normal size is a healthy or a diseased one.

10. The only certain means of proving that the opposite kidney is a healthy one is by draining the diseased kidney through the loin, so that the urine from the opposite kidney alone enters the bladder.

Nephritis, or inflammation of the kidney, as met with in surgical practice, is commonly the result of long-standing disease of the bladder, urethra, or prostate, or of the impaction of a calculus in the ureter or pelvis of the kidney. Traumatic nephritis has already been alluded to under *Injuries of the Abdomen.*

The inflammation, when secondary to other diseases of the urinary organs, may be produced in several ways. Thus, it may be due to —1. Tension in the tubules of the kidney, resulting from obstruction to the overflow of urine consequent upon long-standing stricture of the urethra or prostatic enlargement. Under these circumstances the inflammation falls chiefly on the cortical and medullary substance of the kidney (*interstitial nephritis*). 2. The presence of septic matter in the pelvis of the kidney due to (*a*) the spread of inflammation up the ureter from the bladder, or (*b*) decomposition of pent-up urine behind an impacted calculus in the ureter or pelvis of the kidney. In this case the inflammation is of a septic or suppurative character, and although it may chiefly affect either the lining membrane of the pelvis (*pyelitis*), or the substance of the organ (*suppurative nephritis*), it more generally involves both (*pyelo-nephritis*). At times the pelvis and calices become distended with pus, and the kidney is finally converted into a suppurating cyst (*pyo nephrosis*). 3. Reflex irritation of the kidney through the

PLATE XVIII.

Skiagram of a stone in the left kidney. (Taken by Dr. Hugh Walsham of Mr. Butlin's at St. Bartholomew's Hospital.)

nervous system, as from the passage of a catheter in stricture or enlarged prostate, or the performance of some operation on the urinary organs, as lithotomy or lithotrity. Here the inflammation is usually transitory, unless the kidneys are already suffering from the effects of urinary obstruction, when it may run on to suppuration.

Simple interstitial nephritis usually begins in an insidious manner, the *symptoms* of the kidney mischief being obscured by the primary affection of the bladder or urethra from which the patient is probably suffering. It may be suspected, however, where there is continual loss of strength, increasing pallor and gradual wasting. The urine is passed in large quantities, and is of low specific gravity. Albumen at first is absent, or present only in small quantities, and although later it may be increased in amount, it is often difficult to estimate in consequence of the pus, mucus, or blood which may be present, owing to the diseased bladder or other urinary trouble. Should these troubles not be relieved, the symptoms of the kidney affection become more marked; there is loss of appetite, a furred tongue, nausea, perhaps vomiting, increase of temperature at nights, a hot skin, thirst, and emaciation. This condition may last for months, when the symptoms may gradually subside if the primary trouble can be removed; or it may terminate in exhaustion and death; or in an acute attack of suppurative nephritis.

The *treatment* consists essentially in removing the cause, where this is practicable, and carefully avoiding all sources of irritation that may react through the nervous system of the kidney. Thus, all instrumentation must be done in the gentlest possible manner, and decomposition of the urine prevented by washing out the bladder with antiseptic solutions. The patient at the same time should be kept in bed, and restricted to a non-stimulating and chiefly fluid diet; whilst hot flannels and occasionally dry cups should be applied to the loins.

Suppurative or septic nephritis.—Under this head is included suppuration of the pelvis and of the substance of the kidney, since both, as a rule, are simultaneously affected, and the symptoms are similar or identical. Pyonephrosis is considered separately. Suppurative nephritis generally occurs suddenly in the course of long-standing disease of the lower urinary organs, attended with septic decomposition of the urine in the bladder, whence the now disused term "Surgical kidney." It is probably almost always due to the septic micro-organisms reaching the kidneys from the bladder by the ureters. It is usually preceded by simple interstitial nephritis.

The *symptoms* which frequently first come on after some operative procedure on the urethra or bladder, are usually ushered in by a rigor followed by sweating and fever. The tongue becomes dry and red; the lips and teeth are covered with sordes; the appetite is lost; nausea, vomiting, or diarrhœa sets in, and the patient usually sinks

into a typhoid state and dies. There is no œdema, and the urine usually continues abundant and loaded with pus to the end, though it may at times be diminished in quantity or even suppressed. It may or may not contain blood.

Treatment as a rule is of little avail; but the same general plan should be followed as described under simple interstitial nephritis.

Perinephritis, or inflammation in the retroperitoneal cellular tissue around the kidney, may be: (1) primary, from injury; (2) consecutive to renal suppuration; (3) a secondary extension from the cæcum and appendix, or from the colon, rectum, uterine appendages, gall-bladder, spleen, vertebræ or pleura; (4) pyæmic.

Circumscribed abscess may occur in the kidney-substance or in the cellular tissue around (*peri-nephritic abscess*). It must be distinguished from pyonephrosis, in which the pelvis and calices are distended with pus. *Cause.*—It is generally due in the kidney to injury, pyæmia, or renal calculus. When it occurs in the peri-renal tissue, it may be consecutive to abscess or other disease of the kidney itself; or it may be due to causes independent of the kidney, as cold, disease of the spine and other conditions leading to the formation of abscesses. The *symptoms* are those of deep suppuration, attended with certain peculiarities on account of its situation, which have been referred to (see p. 953). The *treatment* consists in making a free incision into the abscess through the loin.

Hydronephrosis is an over-distension of the pelvis and calices of the kidney with altered urine, and is often bilateral. *Cause.*—(1) Any condition in the bladder, ureter, or pelvis of the kidney, producing mechanical obstruction to the outflow of urine. These conditions may be divided into the *congenital*, such as twists of the ureter, smallness of its vesical orifice, phimosis (Fig. 475), etc.; and into the *acquired*, such as impaction of a calculus in the ureter, enlarged prostate, stricture of the urethra, etc. (2) Any condition in the pelvis or abdomen producing direct pressure on the ureter, such as tumours of all kinds, uterine, ovarian, inflammatory adhesions, etc. *Pathology.*—The pelvis, and subsequently the calices of the kidney, become distended with urine, the cortical substance is destroyed by the pressure of the retained urine, and the whole organ finally converted into an irregular cyst (Fig. 475). The hydronephrotic fluid consists of altered urine, and may contain hardly a trace of urea. *Symptoms.*—When the obstruction is complete, a tumour, which is often of a great size, is found in the abdomen. It may then be mistaken for an ovarian cyst, an hydatid cyst of the liver or omentum, a distended gall-bladder, a splenic tumour, a solid tumour of the kidney, or pyonephrosis. From these a hydronephrotic kidney may generally be distinguished by the colon being in front of it, by the presence of fluctuation, by its dulness to percussion, by its situation in the flank, by its projection more or less in the loins, by the presence of an area of resonance between the hepatic or

splenic dulness according as the right or left side is affected, by bladder symptoms, history of calculus and, perhaps, of blood in the urine, and by the presence of an area of resonance below the tumour and absence of any pedicle leading to the pelvis, by the uterus being free and not displaced, and by the absence of febrile symptoms. When the obstruction is intermittent the tumour periodically shrinks, and at the same time the bladder becomes suddenly filled with urine. *Treatment.*—If the cause, as a stricture,

FIG. 475.—Hydronephrosis, with dilated ureters, bladder and penis, due to phimosis in an infant aged five months. (St. Bartholomew's Hospital Museum, No. 2370 *b*.)

phimosis, etc., can be removed nothing further is required. If the cause is not discoverable the kidney should be cut down upon and drained (see *Nephrotomy*). The pelvis and ureter should then be examined by prolonging the incision. If a calculus is found it should be removed and the pelvis or ureter sutured. If a stricture is detected ureterotomy should be performed ; or the strictured portion excised and either end to end union made or else the upper end implanted in the bladder.

Pyonephrosis is the distension of the pelvis and calices of the

kidney with pus, and the subsequent destruction, more or less complete, of the medullary and cortical substance, the whole kidney being at length converted into a large multilocular cyst. This cyst may rupture into the peritoneal cavity or colon, or into the surrounding tissue, causing a perinephritic abscess. *Causes.*—It may follow pyelitis, owing to the blocking of the ureter with a clot of blood or pus; or it may be engrafted on hydronephrosis, consequent upon tapping or injury. At times it may be the result of tubercle, or of a direct injury of the kidney. *Symptoms.*—In addition to a tumour in the abdomen with characters similar to those of hydronephrosis, there will be pain in the tumour, especially on pressure, febrile disturbance, and if the obstruction of the ureter is incomplete, pus in the urine from time to time. *Treatment.*—Nephrotomy, with removal of any obstruction discovered in the pelvis of the kidney or ureter. If after nephrotomy, however, the cyst does not shrink and cease to suppurate, nephrectomy may have to be done, as otherwise lardaceous disease or hectic may carry off the patient, or blood-poisoning may ensue from the discharge becoming septic, or, as sometimes happens when the obstruction of the ureter is relieved to some extent by the nephrotomy, the decomposing pus may make its way into the bladder, set up cystitis, and the other kidney become affected. Under some circumstances, as where the kidney is reduced to little more than a shell, it will be better at once to perform nephrectomy.

Renal calculi generally consists of uric acid or of oxalate of lime, and are formed by the deposit of the urinary salts, either in the tubules or calices of the kidney. Whilst still small, they may pass down the ureter into the bladder, and subsequently form the nucleus of a vesical calculus, or be voided with the urine. Or they may remain in the kidney, either in its substance, or in the pelvis or one of the calices, and there increase in size by the successive deposit upon them of the urinary salts. They may be single or multiple, and vary in size and shape from a small rounded body the size of a mustard-seed to a large branched mass filling the pelvis and calices (Fig. 476). A renal calculus may set up inflammation of the pelvis of the kidney (*calculous pyelitis*), or of its substance (*simple or suppurative nephritis*), or it may block the ureter, in which case the kidney may become distended with altered urine (*hydronephrosis*), or with pus (*pyonephrosis*), or its excreting and secreting function may be arrested giving rise, if the opposite kidney is absent or diseased, to *calculous anuria*. At times a calculus may exist in the kidney for years, causing little or no damage, or it may by its constant irritation lead to epithelioma of the kidney. Not infrequently there may be a stone in each kidney.

Symptoms.—At times there may be no symptoms, even although the stone is of large size. Generally, however, there will be pain, retraction of the testicle, increased frequency of micturition, and the

presence of blood, pus, or crystals in the urine. The pain, which is worse after exercise, is situated in the loin of the affected side, and is often felt shooting down the course of the ureter to the groin and front of the thigh, but it may be felt in both loins or may shift from one side to the other. In such cases it is probable that there is a stone in both kidneys. Blood is generally present in the urine from time to time, especially after violent exercise, and pus and mucus in varying quantities if pyelitis has been set up may also, as a rule, be detected. The urine, notwithstanding the presence of the pus, is generally acid, and the bladder, prostate, and urethra are found free from disease. The calculus in some cases will be shown by the *x* rays (see Plate XVIII.). It is often difficult to determine which kidney is affected since pain may be felt in both loins. The *x* rays may then be of service, and with the cystoscope blood or pus may perhaps be seen escaping from the ureter of the kidney in which the stone is situated. In the female a catheter may be passed into each ureter and the urine from each examined separately. If still in doubt each kidney may be explored with the hand passed through an incision in the front wall of the abdomen or through an incision in each loin. Should hydronephrosis or pyonephrosis have been produced, a swelling having the characters of a kidney tumour (see *Hydronephrosis*, p. 956) will then be discovered in the abdomen, and if the obstruction of the ureter is complete there may no longer be any pus or blood in the urine. In the latter instance there may be in addition constitutional signs of suppuration (see *Pyonephrosis*). Should the stone escape from the pelvis and enter and pass down the ureter, its passage will be attended with intense pain (*renal colic*), whilst should it be arrested in the ureter and the other kidney happen to be absent or diseased suppression of urine will occur (*calculous anuria*).

FIG. 476.—Renal calculus blocking up pelvis of kidney and commencement of ureter. (St. Bartholomew's Hospital Museum.)

Renal colic.—The pain occurs suddenly, is paroxysmal, and darts towards the groin, testicle or ovary, and thigh, and is accompanied by nausea or vomiting, syncope, profuse perspiration, strangury, and blood and urates in the urine. The temperature is not raised and may be subnormal. After lasting from a few hours to several days the symptoms suddenly cease, owing to the calculus dropping from the lower end of the ureter into the bladder, or if too large to pass beyond the infundibulum, becoming displaced and falling back into the pelvis

of the kidney. Hence successive attacks of renal colic may be due either to the same stone blocking up from time to time the entrance of the ureter, like a ball-valve, or to the passage of different stones.

Calculous anuria is suppression of urine due to the blocking of the pelvis or ureter by a calculus, the other kidney being absent or diseased or more rarely obstructed by a calculus at the same time. The onset is generally sudden and frequently induced by some violent exertion. It is attended with pain, and there may have been previous attacks of renal colic. The anuria is seldom complete, a few ounces or more of pale urine deficient in urea being voided from time to time. Sooner or later, according to the completeness of the obstruction, symptoms of uræmia set in. Although a few cases of spontaneous recovery have occurred, it is usually fatal without surgical interference.

Diagnosis.—A renal calculus may be diagnosed from tuberculous disease of the kidney, which closely simulates it, by the symptoms in calculus being increased by exercise; by the presence of crystals of urates or oxalates in the urine; by the history of attacks of renal colic, and of the passage of small calculi or gravel from the bladder; by the absence of signs of tubercle elsewhere and of the tubercle bacillus in the urine; by the possible discovery of the stone with the *x* rays, and, finally, if still in doubt by an exploratory incision in the loin. A renal calculus may also be simulated by choking of the tubules with urates, by thickening of the renal capsule, by spinal caries and by lumbago.

When the calculus has led to hydronephrosis or pyonephrosis the tumour thus formed has to be diagnosed, not only from a malignant growth and tuberculous disease of the kidney, but also from other abdominal tumours (see characters of renal tumours under *Hydronephrosis*, p. 956).

Renal colic may be simulated by hepatic colic. The latter may generally be diagnosed by the presence of jaundice, distension of the gall-bladder, passage of gall-stones, and the absence of blood, gravel or pus in the urine. When the calculus is impacted in the lower end of the ureter it may be felt by the finger in the rectum or vagina or by the sound in the bladder.

Treatment.—For an account of the preventive treatment of renal calculi a work on Medicine must be consulted. As soon as a calculus is diagnosed the kidney should be exposed, cut into and the calculus removed (see *Nephrolithotomy*). If on cutting into the kidney a stone cannot be felt with the finger a fine bougie should be passed through the incision in the kidney into the ureter, or if the entrance of the ureter cannot in this way be hit off, through a small incision in the back of the renal pelvis. If an obstruction is met with the ureter should be explored with the finger, the wound in the loin being prolonged if necessary in a forward and downward direction past the anterior superior spine of the ilium parallel to

Poupart's ligament as far as the internal abdominal ring. Through this incision the ureter can be followed without opening the peritoneum down to the pelvis almost as far as its entrance into the bladder. A longitudinal incision should be made over the calculus through the wall of the ureter, the calculus removed and the wall of the ureter united by Lembert's suture. If the calculus is impacted in the pelvic portion of the ureter, it should, if possible, be pushed back by the fingers into the abdominal portion and there extracted. If the calculus is impacted at the entrance to the bladder it may be removed through the bladder by suprapubic cystotomy, and in some instances in the female through the vagina or in the male through the perineum, but the vaginal and perineal operations are apt to leave intractable fistulæ. After exposure of the kidney, though no stone is found, the patient often gets relief. In such cases it is probable that the symptoms were due to choking of the tubules of the kidney with crystals of urates or oxalates, and that the manipulation of the kidney freed the tubules. If hydronephrosis or pyonephrosis has supervened, nephrotomy is required, or, if the organ is completely disorganised, nephrectomy. For *renal colic*, hot baths, hot fomentations, and opium or injections of morphia must be given to assuage the pain. In *calculous anuria* the obstructing stone should be at once removed, or if not discovered the kidney drained.

Tuberculous kidney.—This affection may occur in the course of general tuberculosis, or involve the kidney secondarily to the bladder or prostate when both kidneys are usually affected; or it may begin primarily in the kidney and thence spread downwards. In *primary tuberculosis* the disease may at first be limited to a deposit of tubercle in the cortex or in the base of a pyramid, but caseation soon ensues and the disease spreads to the rest of the cortex and pyramids, involves the pelvis, and converts the kidney into a suppurating cyst with caseating walls (Fig. 477). The ureter, whether attacked at the bladder or kidney end, becomes infiltrated with tubercle, thickened, and lined with œdematous tuberculous granulations. Perinephritic abscesses may now form, and finally the patient dies of uræmia, exhaustion, or toxinæmia. The *symptoms* to which tubercle in the kidney gives rise are very similar to those of renal calculus, and it may be impossible to distinguish them. Thus, there is increased frequency of micturition; pus, and at times blood, in the urine, and often pain in the loin; whilst later there will be a tumour in the abdomen with characters like those described under pyonephrosis. The presence of tubercle elsewhere, and of hectic or emaciation, and the discovery of the tubercle bacillus in the urine, will point to the nature of the case. *Treatment.*—The constitutional remedies for tubercle should be employed, and when pyonephrosis or a perinephritic abscess has formed, nephrotomy may be resorted to. When the tuberculous

deposits are limited they may be cut or scraped away, iodoform emulsion applied, and the cut surfaces sutured. Nephrectomy should never be undertaken unless it seems clear that the disease is limited to one kidney, the exception rather than the rule, and a point that can only be ascertained with certainty by exploration through the front wall of the abdomen or through an incision in each loin. In the female the ureters may be catheterised and the urine that escapes from each examined. If that from one side is healthy, the corresponding kidney is probably also sound. Where

Fig. 477.—Tuberculous disease of kidney. (St. Bartholomew's Hospital Museum, No. 2341 *f*.)

the tubercle is extending down the ureter ureterectomy may be also done.

Cysts of the kidney.—Serous and hydatid cysts may occur in the kidney as elsewhere, but their diagnosis is often attended with much difficulty. They are very rare. Cysts of small size are common in connection with some forms of chronic Bright's disease; but these only concern the pathologist. The so-called cystic degeneration, due to urinary obstruction, pyelitis, etc., has already been alluded to.

Tumours of the kidney may be cystic or solid.

(*a*) *Cystic tumours.*—The cystic dilatations known as hydro- and pyo-nephrosis are described at pp. 956, 957, and serous and hydatid cysts are referred to above.

The *multilocular cystic tumour* is of congenital origin, and is

produced by the dilatation of the tubules consequent upon a faulty development or blocking of the collecting tubules. A part or the whole of one kidney or of both kidneys may thus be converted into a number of cysts with a variable amount of intercystic fibrous tissue, which is generally of a simple character but may contain sarcomatous elements. These tumours may be present at birth and obstruct labour or appear during infancy, or it is believed may remain

Fig. 478.—Sarcoma of kidney. The growth, which microscopically is a round-celled sarcoma, only occupies the upper half of the kidney ; the lower half of the organ is free. It was removed from a woman aged 27 years, but recurred within a few months. (St. Bartholomew's Hospital Museum, No. 2391 *b*.)

latent till well on in adult life. Indistinguishable from the foregoing before operation is a congenital cystic tumour developing in the perinephritic tissue either from fœtal remains or from the supra-renal capsule.

(*b*) *Solid tumours* may be innocent or malignant.

Innocent tumours of various kinds, as fibromata and lipomata, have been met with, but may be regarded as little more than pathological curiosities. Adenomata occur as circumscribed tumours consisting of vascular kidney substance, which may break down forming

blood-cysts. They are believed to arise from embryonic remains. Villous papillomata occur in the pelvis of the kidney giving rise to hæmaturia. Tuberculous infiltrations and gummata may cause the kidney to form a large tumour.

Malignant tumours.—Sarcomata of congenital origin may occur in infants and in children, especially girls. They form soft, vascular, rapidly-growing tumours, and are attended by rapid dissemination and emaciation and quick recurrence after removal. A peculiar form containing striped muscle-fibres is known as the *rhabdo-myo-sarcoma*. Sarcomata also occur in adults having similar characters. Carcinomata in the form of epithelioma may occur from irritation of a calculus. The sarcomata and carcinomata are characterised by a swelling in the region of the kidney, dulness in the flank, the presence of the colon in front of them, the absence of fluctuation unless they are of a cystic character, blood in the urine, and rapid emaciation. In carcinoma a varicocele, owing to the large glands in the region of the pelvis of the kidney pressing on the spermatic vein, is not uncommon. *Treatment.*—If the tumour is diagnosed whilst still small, nephrectomy may be done, though an early recurrence is only too probable in the case of sarcoma, especially in infants. In carcinoma the prognosis is more hopeful. When the tumour is of large size and has formed adhesions to the neighbouring parts, it is beyond the reach of legitimate surgery. It has recently been proposed, where the tumour only involves a part of the kidney, to save the healthy portion. That such an operation is possible is well shown in Fig. 478, but seeing how rapidly recurrence takes place, even when the whole kidney is removed, it should only be done when the tumour is well-encapsuled.

Peri-renal tumours.—A cyst or sarcoma may arise in connection with the *suprarenal capsule*, and such a tumour has been removed with the kidney by abdominal nephrectomy. A cystic hygroma, similar to that which occurs in the neck, has been met with in the loin, not attached to the kidney.

Moveable or floating kidney.—A moveable kidney is most common in women, but the condition should not be looked upon as a disease unless it is a source of pain or other inconvenience. It may occur as the result of pregnancy, tight lacing, lifting heavy weights, abdominal distension with flatus, or occasionally of some injury, or it may form part of a general prolapse of the abdominal viscera called *Glénard's disease*. The kidney, which may be recognised by its shape, and by the fact that it can be reduced into its proper position when the patient is lying down, may either float freely in the abdomen, being merely held by a long mesonephron, or it may slide up and down behind the peritoneum in a track resembling a large tendon sheath. The symptoms complained of are discomfort, pain, nausea or vomiting, sweating and faintness. At times a floating kidney may suddenly swell up owing to distension

by urine consequent upon a kink in the ureter and as suddenly shrink to its normal size when the kink is relieved, the bladder becoming simultaneously distended with urine. At other times, owing to torsion of the pedicle, acute symptoms resembling those due to strangulation of the intestine may be set up, or pain and hæmaturia may occur when crystals of urates collect in the tubules or a stone forms in the pelvis. Pain caused by a moveable kidney alone should disappear when the patient is lying down and recur when she gets about; whereas pain due to uratic concretions or stone is still felt when the patient lies down, though it is worse when she moves about. The condition must be distinguished from chronic disease of the gall-bladder, appendix, or female pelvic organs. *Treatment.*—A belt should first be tried and the bowels kept open. In severe cases the kidney may be exposed through a lumbar incision and fixed by sutures (see *Nephrorrhaphy*).

Suppression of urine is the term applied to the non-secretion of urine by the kidneys, and must not be confounded with *retention* of urine, in which the urine is secreted as usual, but its passage from the bladder is obstructed. In the former the bladder is empty; in the latter distended. Suppression as met with in surgical practice is generally due to the shock following an operation on or injury to the urinary organs in a patient suffering from chronic renal disease, or to the sudden impaction of a calculus in the ureter, the opposite kidney being absent or diseased (see *Calculous anuria*), or to the ureters being compressed by an abdominal or pelvic tumour. If not relieved, coma, convulsions, and death from uræmia quickly ensue. *Treatment.*—Dry or wet cupping the loins, hot vapour baths, free purging as by elaterium or croton oil, injections of pilocarpine, and hot enemata per rectum, are at times successful in relieving the congested kidney. If a calculus is present in the ureter it must at once be removed (see *Calculous anuria*, p. 960). If the ureters are compressed by a tumour, etc., laparotomy should be performed, and an endeavour made to free the ureters.

Operations on the Kidney.

Aspiration of the kidney is rarely performed now. It was formerly done either for the purpose of diagnosing a renal swelling, or for the relief of such affections as hydronephrosis, pyonephrosis, or hydatid or blood cysts.

Nephrotomy consists in making an incision into the kidney for the purpose of draining away the fluid or pus in the case of hydronephrosis, pyonephrosis, hydatid cyst, abscess, &c. The tumour having been exposed by an incision like that for nephro-lithotomy, the cyst is cut into and the fluid allowed to run out. The interior of the cyst is next explored with the finger and a sound, and a bougie passed down the ureter to ascertain if it is patent or

obstructed. If a stone is met with it should be removed in the way mentioned below; if a stricture is discovered it may be dealt with as described under *Ureteroplasty*, p. 553. The cyst is now thoroughly irrigated with some antiseptic solution and insufflated with iodoform, a large-sized drainage-tube inserted into it, and voluminous dressings of absorbent gauze or the like applied to receive the subsequent discharges.

Nephro-lithotomy consists in cutting into a kidney for the purpose of extracting a calculus. The kidney is best exposed by making an incision from the outer edge of the erector spinæ just below the last rib obliquely forwards and downwards to a little above and in front of the anterior superior spine of the ilium. The advantage of this incision over the vertical lumbar incision formerly employed is that it can be prolonged if necessary parallel to Poupart's ligament as far as the internal abdominal ring for the purpose of exploring the ureter. The muscles and transversalis fascia having been divided and the colon if necessary held aside, the fascial investment of the kidney is drawn into the wound, opened, and the kidney fat comes into view. The kidney and renal pelvis are now palpated with the finger, as advised by Mr. Morris, before the connections of the organ are disturbed, lest any small stone should slip into the ureter. The kidney is next freed all round with the fingers from the peri-renal fat and drawn out of the wound on to the abdomen if, as is often the case, this can be done without putting excessive strain on the pedicle. An incision is now made through the convex margin of the kidney, or over the stone if one is felt, the hæmorrhage, which at first is sharp, being controlled by pressure with the fingers on the pedicle. The stone if discovered is then removed with suitable forceps. If a stone is not felt the pelvis and calices should be explored with the finger and sound and a bougie passed into the ureter, as already described under *Treatment of Renal Calculus* (p. 960). After the stone has been removed the interior of the kidney should be well irrigated with a hot antiseptic lotion to clear it of *débris* and clots, and if the incision has been made through the pelvis this should be closed by Lembert's sutures, a drainage-tube placed in the external wound, the rest of the wound brought together by deep sutures and an antiseptic absorbent dressing applied. Some urine may escape at first through the wound, but will soon cease to do so if the ureters are patent.

Nephrectomy, or removal of the kidney, may be done for—1. A large renal calculus with extensive destruction of the kidney substance. 2. Unilateral tuberculous disease with exhausting discharge. 3. Malignant and other tumours. 4. Intractable renal fistulæ left after nephrotomy for hydronephrosis or pyonephrosis. The operation may be done without opening the peritoneum either by a lumbar or a lateral incision, or through the peritoneal cavity, the incision being then made either in the linea alba or linea

semilunaris. Before removing a kidney the surgeon should make sure that a kidney exists on the opposite side, and is fairly healthy. This may be ascertained in some measure by estimating the amount of urea secreted, by passing a catheter into the ureters in females and collecting and testing the urine thus obtained, or better, by exploring from the front through an abdominal incision.

The *extra-peritoneal operation.*—If the incision is made in the lumbar region it may be vertical, T-shaped, or oblique. If the lateral incision is chosen it is made in the way described under *Nephro-lithotomy;* it combines the facilities of the intra-peritoneal and the greater safety of the lumbar incision in that it does not involve opening the peritoneal cavity. The kidney having been exposed by any of these incisions, the capsule should be opened, the finger introduced, and the kidney enucleated from its capsule; the pedicle, including the renal artery and vein, should then be transfixed by an aneurysm-needle, securely tied with a silk ligature passed round them, and the ureter secured separately in a similar way. The kidney may now be removed by cutting through the pedicle with scissors, and the wound drained and dressed antiseptically.

The *intra-peritoneal operation.*—This consists in opening the peritoneal cavity in the linea semilunaris or even in the linea alba, pushing the intestines aside, and then exposing the kidney by cutting through the peritoneum in front of it external to the colon. The vessels and the ureter are tied separately, the kidney removed, and the peritoneum drawn together by sutures; the peritoneal cavity sponged dry, and the abdominal wound closed in the usual way. A drain-tube is passed by some surgeons through a counter-opening in the loin, and the end of the ureter brought out of the wound.

The *dangers of nephrectomy* are—1. Severe shock. 2. Excessive hæmorrhage. 3. Suppression of urine from disease or absence of the opposite kidney. 4. Septic peritonitis. 5. Laceration of the colon. 6. Inclusion of the vena cava in the ligature of the pedicle and injury of the duodenum in operating on the right side.

Nephropexy or nephrorrhaphy is an operation for fixing a floating or moveable kidney. It should be done only when there is much pain and constant suffering which palliatives, such as wearing a supporting belt, have failed to relieve. Edebolds advises that the patient should lie prone over an air bolster eight inches in diameter, in order to get the kidney well back into the loin. The kidney is exposed through a lumbar incision; the fat stripped off, and three or four sutures of kangaroo-tail tendon passed through the capsule and cortex of the organ, and then through the cut edges of the transversalis fascia and aponeurosis of the tranversalis muscle. The method of inserting the sutures is shown in Fig. 479. The sutures do not become the nuclei of calculi as was anticipated when the method was first introduced by Mr. Henry Morris. The wound may either be completely closed or the hinder end plugged with

aseptic gauze, so as to insure a thicker scar than that resulting from primary union. Should there be any suspicion that the symptoms may in part depend on uratic deposit or possibly on a small calculus, an incision should be made into the kidney, and the pelvis explored with the finger and a sound, and washed out. Some urine may escape at first, but soon ceases to do so. If nothing is found the little operation will do no harm, and will tend to more firmly

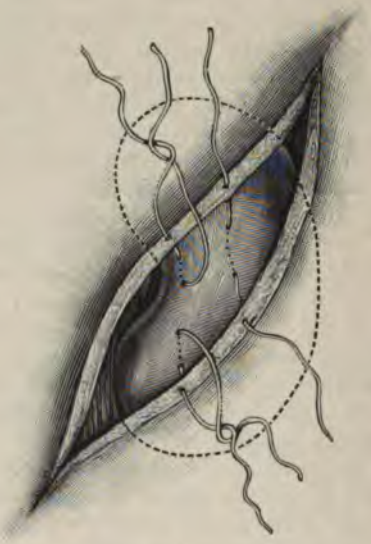


Fig. 479.—Mr. Henry Morris's method of fixing a moveable kidney. (Morris's Renal Surgery.)

fix the kidney. The patient should remain in the recumbent posture for a month. If the foregoing precautions are observed failure is rare.

DISEASES OF THE URETERS.

Dilatation of the ureter.—A pelvic tumour, especially a large uterine myoma or cancer, may compress one or both ureters so that they may be dilated up to the size of a coil of intestine. When both ureters are found so dilated in the course of an hysterectomy the operation had better be abandoned on account of the probable atrophy of the cortex of the two kidneys, and of the likelihood of suppression of urine being excited by the shock. The ureters may also become dilated subsequent to hypertrophy of the bladder and to enlarged prostate. They may sometimes be felt by rectal examination under an anæsthetic, or in thin subjects through the

abdominal wall, by rolling them on the psoas muscle. If found dilated all operative procedures should be limited to what is absolutely necessary.

A stone in the ureter may sometimes be felt through the abdominal wall, especially by bi-manual examination with a finger in the vagina or rectum. It may also be struck when a probe is passed downwards from the pelvis of the kidney. The symptoms to which it gives rise and the method for its extraction have already been discussed under *Renal Calculi* (p. 960).

Tuberculous disease of the ureter may be secondary to tuberculous disease of the kidney or of the bladder. The ureter becomes thickened and its mucous membrane converted into tuberculous granulation-tissue. Where the tubercle is extending down the ureter from the kidney the diseased portion should be cut away in order to prevent the disease spreading to the bladder and thence to the opposite kidney.

Stricture of the ureter, as the result of the contraction of inflammatory adhesions or of injury during a pelvic operation, is occasionally met with, and may give rise to hydronephrosis or pyonephrosis. When situated near the infundibulum the stricture has been successfully treated by division and suture (see *Ureteroplasty*).

Operations on the Ureters.

Ureterotomy, or cutting into the ureter for the purpose of removing a stone or dividing a stricture has been successful in recent years in obviating the sacrifice of the kidney in hydronephrosis and pyonephrosis, and in saving life in calculous anuria.

Ureterostomy consists in dividing the ureter and suturing the proximal end to the wound in the loin. It has been employed where ureterotomy was unsuccessful in clearing the ureter from an obstruction low down, and the condition of the opposite kidney contra-indicates nephrectomy.

Ureteroplasty consists in dividing a stricture by making a longitudinal incision, and closing the incision with Lembert's sutures transversely, after the manner of pyloroplasty for stricture of the pylorus (p. 836). By its means strictures of the upper portion of the ureter have been successfully overcome, and in hydronephrosis and pyonephrosis, kidneys which would otherwise have been sacrificed have been saved.

Ureteral anastomosis.—The methods for restoring a divided or ruptured ureter are described under *Injuries of the Ureter* (p. 533).

Ureterectomy is the operation of removing a portion or the greater part of the ureter. It has been successfully employed in tuberculous disease extending downwards from the kidney towards the bladder.

URINARY DEPOSITS AND CALCULI.

Urinary deposits are divided into the unorganised and the organised. A. The *unorganised* consist of the urates, the uric acid, the oxalate of lime, the phosphates, the cystic oxide, the xanthin or uric oxide and the carbonate of lime. Only the more common of these are described.

1. The *urates* formerly called *lithates*, are the most common of the urinary deposits, and are formed by the combination of uric acid with ammonia, soda, or lime. They occur in acid urine as an amorphous sediment, varying in colour from a white or a pale fawn to a brick-dust red. They appear only as the urine cools, and disappear again on the application of heat, or on adding alkalies. Though generally amorphous they sometimes present the crystalline

FIG. 480.—Urates. (Bryant's Surgery.)

FIG. 481. — Uric acid crystals. (Bryant's Surgery.)

forms seen in Fig. 480. The urate of ammonia occurs in alkaline urine.

2. The *uric acid* deposits, which are the next most common, occur only in very acid urine, as a yellowish-pink, red, or brick-dust red crystalline sediment. The crystals are often of large size, and the deposit is then known as *red sand* or *gravel*. They usually occur as rhombic prisms, or long oval plates with acute angles, and are often mixed, forming rosettes. The various kinds are seen in Fig. 481. They are soluble in alkalies. The *causes* of the presence of uric acid, as well as of the urates, are:—1. Rapid tissue-waste, as in fevers; 2. Over-indulgence in animal food; 3. Dyspepsia; 4. Congestion of the kidney; 5. Gout; and 6. Deficient action of the skin.

3. The *oxalate of lime* is a crystalline deposit and assumes two forms, the octahedral and the dumb-bell crystals (Fig. [illegible]). On holding the urine up to the light the crystals are [illegible]s

minute shining particles. The *causes* are :—1. Nervous exhaustion from overwork or sexual excesses. 2. Dyspepsia induced by saccharine food, excess of alcohol, or a vegetable diet.

4. *Phosphatic* deposits occur in three forms, (*a*) phosphate of

FIG. 482.—Crystals of oxalate of lime. (Bryant's Surgery.)

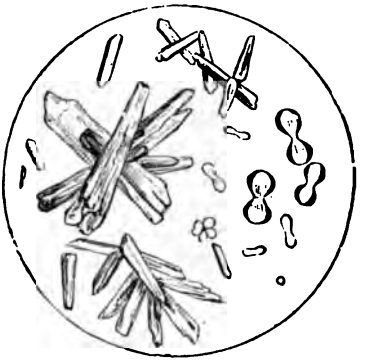


FIG. 483.—Phosphates of lime. (Bryant's Surgery.)

lime, (*b*) phosphate of ammonia and magnesia, or triple phosphates, (*c*) the two former mixed, or the fusible phosphates. (*a*) *Phosphate of lime* forms a white cloud or amorphous deposit of pale granules

FIG. 484.—Phosphates of ammonia and magnesia (triple phosphates). (Bryant's Surgery).

or spheroids, two of which adhering form the so-called false dumb-bell ; or a crystalline deposit of six-sided prisms collected into sheaths or bundles (Fig. 483). It may be mistaken for albumen, or when in considerable quantities for pus or mucus. The urine is usually alkaline, but may be neutral or even feebly acid. (*b*) The

ammonio-magnesium phosphates occur in the form of large triangular prisms with truncated extremities; as four-sided prisms; as six-sided plates; and as foliaceous stellar prisms on adding ammonia (Fig. 484). The urine is natural in colour, neutral or alkaline, with a fœtid ammoniacal odour. *Causes.*—Phosphatic deposits are due to local disease or injury of the urinary organs, such as may be induced by spinal disease, a foreign body in the bladder, &c. The mucus or bacteria in the bladder decompose the urea into carbonate of ammonia, which converts the soluble acid phosphates into insoluble alkaline phosphates.

Carbonate of lime, *cystic oxide*, and *xanthin* or *uric oxide*, are too rare to require description.

B. *The organised deposits.*—To these belong pus, blood, mucus, epithelium, renal casts, spermatozoa, and organisms. *Pus* occurs as a thick sediment, and may be recognised by the urine containing albumen, and by the microscopical appearance of the pus corpuscles (p. 21). It may be due to cystitis, pyelitis, gonorrhœa, leucorrhœa, or to abscess in any part of the urinary tract. Urine containing *mucus* becomes gelatinous and ropy on adding liquor potassæ. *Blood* may be recognised by the urine being smoky or red, by the ozonic ether test, and by the microscope and spectroscope. See *Hæmaturia* (p. 958). *Epithelium*, *renal casts*, *spermatozoa*, and *organisms*, may be detected by the microscope.

Urinary calculi are commonly spoken of as renal, vesical or prostatic, according as they occur in the kidney, bladder or prostate. *Renal calculi* are formed in the kidney, and have already been described (p. 958). *Prostatic calculi* are formed in the racemose glands of the prostate, and will be further referred to under diseases of that organ (Fig. 502, p. 1008). *Vesical calculi* may originate in the bladder, or, as is more commonly the case, in the kidney, whence they pass into the bladder, and there increase in size by the successive deposit upon them of the same or other of the urinary salts. The calculi most frequently met with in this situation are (1) the uric acid, (2) the oxalate of lime, and (3) the fusible or mixed phosphates. The rarer forms are (4) the urate of ammonia; (5) the cystic oxide or cystine; (6) the phosphate of lime; (7) the phosphate of ammonia and magnesia, or triple phosphate; (8) the carbonate of lime; (9) the xanthin or uric oxide; (10) the fibrinous; (11) the blood; (12) the uro-stealith; and (13) the silicious. The last seven, being exceedingly rare, are not described.

1. **The uric acid calculi** are the most common. They are generally of moderate size, oval, and laterally compressed, of a nut-brown colour, smooth or finely granular, moderately heavy and hard, and laminated on section. They are completely destroyed in the blow-pipe flame, giving off a smell of burnt feathers. They are insoluble in weak hydrochloric acid, but soluble in warm alkalies. When treated by nitric acid and evaporated to dryness,

on the addition of a drop of ammonia a purple colour is produced (*murexide test*). The nucleus is usually composed of uric acid, sometimes of oxalate of lime, and is generally formed in the kidney. These calculi occur most frequently in *youth* and *middle age*.

2. **The oxalate of lime** or **mulberry calculi** (Figs. 485, 486), as they are often called from their resemblance to a ripe mulberry when first removed covered with blood from the bladder, are generally of moderate size, globular in shape, usually of a dark-brown or mahogany colour, rough and tuberculated, very hard and heavy, and crystalline on section. They are only partially destroyed in the blow-pipe flame, the residue (carbonate of lime) being alkaline and effervescing with an acid. They are insoluble in acetic acid, but soluble in hydrochloric acid. The nucleus is generally composed of oxalate of lime, but may consist of uric acid or urate of ammonia.

FIG. 485.—Oxalate of lime calculus.

FIG. 486.—Section of oxalate of lime calculus.

The nucleus is usually formed in the kidney. These calculi are most frequent in *middle age*.

3. **The phosphatic calculi** are of three kinds :—(*a*) the phosphate of lime or earthy phosphate ; (*b*) the ammonio-magnesian or triple phosphate, and (*c*) the phosphate of lime with the ammonio-magnesian phosphate, the mixed or fusible phosphate. Of these the last is the only common form. It is usually of large size and of white colour, smooth, soft, friable, earthy and laminated on section, and of irregular shape, taking that of the nucleus on which it is formed ; it fuses when heated in the blow-pipe flame ; is insoluble in warm alkalies, but is soluble in acetic acid. The nucleus is composed of uric acid, oxalate of lime, or of some foreign body other than a calculus, as a piece of catheter, hair-pin, a clot of blood, or fibrin. It occurs most frequently in the *later* periods of life, and is then generally produced as follows :—A calculus or other foreign body irritates the mucous membrane of the bladder, and a secretion of mucus is, in consequence, poured out. This mucus decomposes the urea contained in the urine into carbonate of ammonia and water. The carbonate of ammonia unites with the acid phosphates, and an insoluble mixed phosphate of ammonia, magnesia and lime is thrown down and deposited on the foreign

obstructed. If a stone is met with it should be removed in the way mentioned below; if a stricture is discovered it may be dealt with as described under *Ureteroplasty*, p. 553. The cyst is now thoroughly irrigated with some antiseptic solution and insufflated with iodoform, a large-sized drainage-tube inserted into it, and voluminous dressings of absorbent gauze or the like applied to receive the subsequent discharges.

Nephro-lithotomy consists in cutting into a kidney for the purpose of extracting a calculus. The kidney is best exposed by making an incision from the outer edge of the erector spinæ just below the last rib obliquely forwards and downwards to a little above and in front of the anterior superior spine of the ilium. The advantage of this incision over the vertical lumbar incision formerly employed is that it can be prolonged if necessary parallel to Poupart's ligament as far as the internal abdominal ring for the purpose of exploring the ureter. The muscles and transversalis fascia having been divided and the colon if necessary held aside, the fascial investment of the kidney is drawn into the wound, opened, and the kidney fat comes into view. The kidney and renal pelvis are now palpated with the finger, as advised by Mr. Morris, before the connections of the organ are disturbed, lest any small stone should slip into the ureter. The kidney is next freed all round with the fingers from the peri-renal fat and drawn out of the wound on to the abdomen if, as is often the case, this can be done without putting excessive strain on the pedicle. An incision is now made through the convex margin of the kidney, or over the stone if one is felt, the hæmorrhage, which at first is sharp, being controlled by pressure with the fingers on the pedicle. The stone if discovered is then removed with suitable forceps. If a stone is not felt the pelvis and calices should be explored with the finger and sound and a bougie passed into the ureter, as already described under *Treatment of Renal Calculus* (p. 960). After the stone has been removed the interior of the kidney should be well irrigated with a hot antiseptic lotion to clear it of *débris* and clots, and if the incision has been made through the pelvis this should be closed by Lembert's sutures, a drainage-tube placed in the external wound, the rest of the wound brought together by deep sutures and an antiseptic absorbent dressing applied. Some urine may escape at first through the wound, but will soon cease to do so if the ureters are patent.

Nephrectomy, or removal of the kidney, may be done for—1. A large renal calculus with extensive destruction of the kidney substance. 2. Unilateral tuberculous disease with exhausting discharge. 3. Malignant and other tumours. 4. Intractable renal fistulæ left after nephrotomy for hydronephrosis or pyonephrosis. The operation may be done without opening the peritoneum either by a lumbar or a lateral incision, or through the peritoneal cavity, the incision being then made either in the linea alba or linea

wires pass up the tube from the lamp and are attached to the cables from the battery. By means of a switch the circuit is completed and the lamp made to glow. In order to use the apparatus, the urethra must be of full size, any stricture that may be present, therefore, must first be dilated. The bladder should be distended with clear water after it has been washed out. A general anæsthetic is as a rule desirable, but cocain may be used if the urethra is tolerant of instrumentation. Not more than half a grain in a 2 per cent. solution should be injected, since it is rapidly absorbed from the urethra and fatal poisoning has attended the employment of a grain. It is best to prepare the patient by rest for a day in bed, or

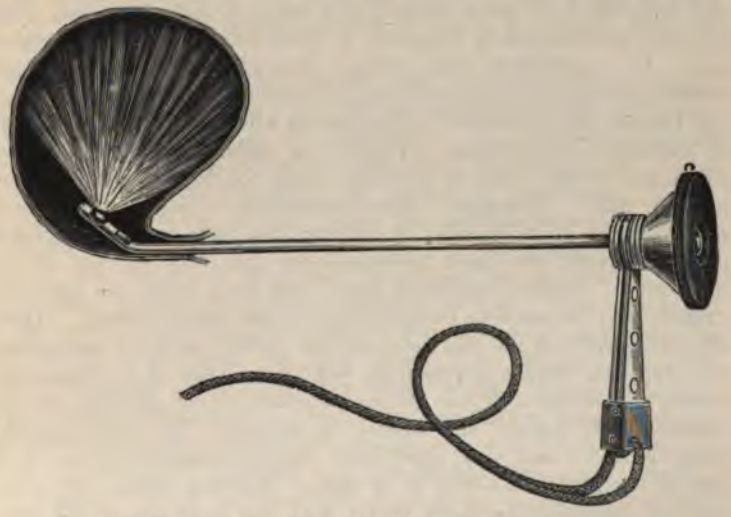


Fig. 487.—Cystoscope for examining the interior of the bladder.

for a longer period if the urine contains blood. The tube of the cystoscope should be warmed and lubricated with glycerine, and the lamp not made to glow till the instrument is in the bladder. Whilst glowing it should not be brought into contact with the bladder-walls, and should only be kept glowing for a few minutes at a time. It should be extinguished and time given for it to cool before the instrument is withdrawn, so as not to burn the urethra. The mucous membrane is got into focus and the tube rotated on the eye-piece to get the ureteral orifices into view, from which the urine may be seen to be expelled in jets, and perhaps on one side tinged with blood. The fundus is next inspected and then the tube is turned round to examine behind the prostate. In this way the floating villous processes of a growth may be seen, or a small stone may be detected in a pouch or an ulcer discovered. A prominent fold of the normal

mucous membrane is not likely to be mistaken for disease if a good cystoscope is used and some experience has been acquired.

For catheterising the ureters the cystoscope is fitted with a fine catheter, so that when the orifice of the ureter is in view the catheter may be pushed on into the opening.

Extroversion or **ectopia vesicæ** is a malformation in which in consequence of an arrest in the development of the anterior wall of the allantois which forms the front of the bladder and of the corresponding part of the abdominal parietes, the posterior wall of the bladder is pushed forward by the pressure of the abdominal viscera, and protrudes as a red velvety tumour. It usually occurs in males and is associated with epispadias, or absence of the upper wall of the urethra, and with failure of union of the pubic bones at the symphysis. The testicles are frequently retained in folds like the labia on either side. It is attended with extreme discomfort from the constant dribbling away of the urine from the mouths of the ureters, which can be seen on the surface of the tumour when the trigone is exposed by pulling down the penis. There is no umbilicus, but at birth the lower part of the cord is stretched over the bladder forming the anterior wall. *Treatment.*—Many operations, having for their object the closing in of the bladder by flaps of skin taken from the adjacent abdominal wall, have been performed for the relief or cure of the deformity. Various attempts have also been made to turn the ureters into the colon or rectum, but without much success. Trendelenburg reduces the gap between the pubic bones by separating the sacro-iliac synchondroses from behind, so that at a subsequent sitting the margins of the mucous surface of the bladder can be brought into contact and united by sutures. The newly-formed bladder is in this way lined with mucous membrane instead of having its front wall closed in by skin. Mikulicz attains the same end by detaching the pubic crests with the insertion of the recti muscles and carrying them into contact in the middle line. The objection to the skin flap is the growth of hair into the bladder at puberty and its incrustation with phosphates. If successful in closing the bladder in one of these ways the open urethra may be subsequently converted into a tube by paring the edges and uniting them by suture over a catheter. But no patient has been able to do without a urinal, and in many cases a prolapse of the mucous membrane of the bladder has re-established the deformity. Moreover the mortality from septic inflammation after this operation has been very great. Another plan tried has been to dissect away the bladder and join the two ureters to the upper end of the urethral groove, which is then closed, so that the patient can more easily wear a urinal since the urine is conducted to the end of the penis.

Maydl's operation is perhaps at present the most successful one. The trigone with the ureters attached to it is raised and implanted into the sigmoid flexure or beginning of the rectum, which lies

immediately behind. This can be done without opening the peritoneal cavity at all, or only to a limited extent. The skin can be brought together and the urethra covered in to form a penis at a subsequent operation. The ureteral valve at the junction of the trigone protects against regurgitation and so prevents the septic pyelitis which followed the implantation of the ureters alone. The patients have continued in comparative comfort years after the operation, the bowels being moved every two to four hours.

If no operation be undertaken a properly shaped urinal must be worn, to hide which the boy may wear a kilt.

Cystitis, or Inflammation of the Bladder, may vary from the mildest catarrh to the most intense inflammation, involving not only the mucous membrane but the other coats of the organ as well. For the purpose of description, however, it may be divided into the Acute and Chronic.

Acute cystitis.—*Causes.*—In its most intense form it is nearly always the result of septic injury, as the passage of instruments, the retention of a catheter in the bladder, or the irritation of sharp fragments of a crushed calculus. The most frequent cause is the extension of inflammation from the urethra in gonorrhœa. In all of these the cystitis depends upon the introduction of infective micro-organisms into the bladder. In its milder forms it may be due to the exhibition of certain medicines, as cantharides; and occasionally in gouty subjects to exposure to cold. After fractures of the spine cystitis is very liable to occur even where aseptic catheters are employed. In such cases it is probable that the septic organisms make their way along stringy mucus adhering to the walls of the urethra, or that aseptic catheters are fouled by organisms about the prepuce and meatus. In every case, therefore, before an instrument is passed into the bladder, the glans, meatus, and prepuce should be carefully cleaned by antiseptic lotions, and in fracture of the spine the penis should be kept in an antiseptic dressing.

Pathology.—In the milder forms the inflammation is limited to the neck of the bladder and to the mucous membrane only. In the worst forms it involves the whole bladder, and extends to the muscular or even the peritoneal coat. In addition to the ordinary cocci of suppuration, the bacillus coli, the bacillus of typhoid, and some other organisms have been met with. In gonorrhœa it may be the gonococcus alone or a mixed infection that produces the cystitis. It may terminate in 1, resolution; 2, chronic cystitis; 3, ulceration or gangrene of the mucous membrane; 4, abscess in the walls of the bladder; 5, inflammation of the kidneys, or more rarely of the peritoneum; and 6, sapræmia, produced by the absorption of the products of the decomposing urine.

Symptoms.—In the acutest forms there is intense pain in the perineum and above the pubes, and strangury, *i.e.*, a continual

desire to void urine, which is passed drop by drop in a spasmodic manner; whilst there is high fever, rapidly running into a typhoid type. In the less acute or more common forms micturition is still very frequent, occurring with increased pain as soon as a little urine has collected in the bladder, in consequence of the stretching of the inflamed mucous membrane. The urine is scanty, high-coloured, often blood-stained, and mixed with mucus and pus. The fever, though generally high, is less marked than in the acuter cases, and may be of a mere transitory character.

Treatment.—The cause, if possible, should be removed. Thus, if there are fragments of calculus in the bladder, they should at once be extracted by the large evacuating catheter, any that cannot be got away being crushed; or perhaps better, the bladder may be opened by a median incision in the perineum and thoroughly washed out. If a catheter has been tied in, it should at once be withdrawn. Hot sitz-baths should be given night and morning, leeches applied to the perineum, suppositories of morphia (gr. $\frac{1}{2}$) placed in the rectum, and salicylate of soda (grs. x.), salol (grs. x.), urotropine (grs. v.), hyoscyamus and, if the urine be acid, alkalies, administered to relieve strangury. All stimulants should be avoided, the diet restricted to milk, and the bladder washed out with hot water, or when the urine is decomposed, with a weak antiseptic lotion as boric acid, salol, permanganate of potash or sulphocarbolate of zinc (2 per cent.), etc. If washing out increases the irritation, the bladder in severe cases should be drained by an incision in the perineum.

If the bladder is large and the patient can be well nursed, suprapubic drainage may be instituted. A small hypogastric incision is made into the bladder and a rubber tube inserted which is connected by glass junctions and tubing with a vessel under the bed. Continuous suction may be kept up on the principle of Sprengel's pump: a glass T-piece has its vertical arm joined to the tube in the bladder, whilst through the cross fluid is made to flow from an irrigating vessel above the head of the patient into a vessel under the bed, and when this flow is regulated, urine will be sucked out of the bladder as fast as it enters. The pubic hair must first be shaved and the abdominal wall frequently washed with soap and water and dusted with zinc and starch powder, or wiped over with olive oil and then dusted with dermatol; whilst little pads of peat moss or other absorbent material are packed round the tube to soak up any urine which leaks out beside it. In this way eczema, ulceration and sloughing from the irritation of leaking urine in a weakly patient may be prevented.

Chronic cystitis is much more frequent than the acute variety, and in its mildest form is known as catarrh of the bladder. *Causes.*—It may be a sequel to an acute attack; or it may be chronic from the commencement, and may then be due to a stone

or other foreign body or a growth in the bladder, obstruction to the urinary outflow, as from an enlarged prostate or stricture of the urethra, the extension of gonorrhœa, paralysis, over-distension or atony of the bladder, or the spread of inflammation from the neighbouring organs. It is common after fracture of the spine involving the cord. Like the acute, it may be set up by a septic instrument.

Pathology. — The mucous membrane is thickened, velvety, mottled with patches of a dark-slate or red colour, and may be covered with muco-pus and sometimes with a deposit of phosphates, or it may even, in places, be destroyed by ulceration. The muscular coat, where there has been obstruction to the outflow, becomes thickened and fasciculated, the hypertrophied fibres giving the interior of the bladder a columnar and rugose appearance. In places the mucous membrane may protrude between the fasciculi of the muscular coat, forming sacculi, in which stale urine may accumulate, and in which calculi may form or become lodged. If the cystitis is allowed to continue, the kidneys become affected (*pyelo-nephritis*).

The symptoms are similar to those of acute cystitis, but are much milder in intensity. Thus, there is increased frequency of micturition, the patient, perhaps, having to make water every hour or half-hour, the desire to do so being generally so urgent that he is unable to control it. This, as in the acute variety, is due to spasm from the stretching of the inflamed mucous membrane as soon as a few ounces of urine collects. The pain usually ceases immediately the bladder is relieved. The urine is characteristic; it generally contains large quantities of ropy mucus, pus, and phosphates of lime, which form, on standing, a thick deposit at the bottom of the containing vessel. It is often alkaline, and sometimes highly ammoniacal and offensive from the decomposition of the urea into carbonate of ammonia. This decomposition is brought about by fermentation, probably set up by the presence of micro-organisms that have gained admission either by the use of a contaminated catheter, or by making their way along the stringy mucus that may hang about the urethra.

Treatment.—As in the acute form the cause, as stricture, stone, etc., must first be removed, as where this is impracticable the treatment at best can only be palliative. The diet should be unstimulating, and alcohol in any form, as a rule, forbidden. A purely milk diet is at times most successful. Internally, besides those mentioned for acute cystitis, such medicines as buchu, uva ursi, balsam of copaiva, salol and chlorate of potash should be given where thick ropy mucus is passed with the urine; and benzoic acid, which in its passage through the system is converted into hippuric acid, or boric acid (gr. xv. to ʒj.), or acid sodium phosphate (NaH_2PO_4 ʒj. to Oj.), may be tried when the urine is alkaline. Locally, the bladder should

be washed out twice a day with some antiseptic solution, as of boric acid (gr. xx. to ℥j.), nitric acid, corrosive sublimate (1 in 2,000), quinine (gr. ii to ℥j), nitrate of silver (gr. i. to ℥j.), etc. The best results are sometimes obtained from water as hot as can be borne. Great care should be taken that all instruments are rendered thoroughly aseptic before use. In severe cases, where other means have failed, the bladder should be placed at rest by perineal or suprapubic cystotomy and subsequent drainage for some weeks as described under acute cystitis.

Irritability of the bladder, by which is meant a too frequent passing of water, is often spoken of as a disease; but is no more so than is pain, since it is only a symptom either of disease of the urinary organs, or of some general state of the system, as hysteria, Bright's disease, etc. The cause should be sought and treated.

Inversion of the bladder only occurs in the female (see *Female urethra*), and in males with hypospadias.

Atony and **paralysis** of the bladder. Both these terms are applied to a want of sufficient contractile power in the muscular coat to expel the contents of the bladder; but in *atony* the want of power is the result of loss of tone in the muscular fibres, while *paralysis* is due to the failure of nervous influence. Both conditions must be distinguished from the mere inability of the bladder to empty itself on account of obstruction to its outlet. (See *Retention.*)

Atony may be due to—1. Simple over-distension, consequent upon the patient having voluntarily or compulsorily held his urine for too long a period, whereby the muscular fibres are over-stretched and unable to recover themselves. 2. It may be the result of gradual distension owing to enlarged prostate or stricture. In consequence of the obstruction, the bladder does not empty itself, but some urine remains after every act of micturition; the amount retained gradually increases, the bladder becomes distended, and its fibres, if the patient is old, become stretched, and lose their tone instead of becoming hypertrophied as would happen in a young and healthy person. 3. Again, atony may be due to cystitis, owing to the inflammation having spread to the muscular coat, which then undergoes fibroid or fatty changes.

Symptoms.—The patient complains of inability to hold his urine, or that it constantly dribbles away, or that he has to pass it very frequently. The involuntary flow occurs at first during sleep; afterwards on any exertion causing contraction of the abdominal muscles. These symptoms, although often improperly spoken of as incontinence, are really those of retention, the bladder being fully distended, but unable to empty itself, and the excess flowing involuntarily away.

The *treatment* consists in passing a catheter at regular intervals and as often as may be necessary to completely empty the bladder; whilst in the meantime, the condition leading to the atony must

be treated by appropriate means. Thus, if the result of over-distension, strychnine and galvanism or ergot (ext. ergot. liq. 5js. vel 5j.) may be tried; if the result of gradual distension from enlarged prostate or stricture, these conditions must be treated in the way mentioned under their respective heads. In both paralysis and atony, cystitis, dilatation of the ureters, pyelitis, and disorganisation of the kidney rapidly ensue if the cause of the bladder trouble cannot be relieved.

True paralysis of the bladder is nearly always the result of disease or injury of the brain or spinal cord, and is not met with except in general paralysis. The bladder being paralysed cannot empty itself, and becomes distended as in atony; and when it can hold no more, the excess overflows through the sphincter, which is also paralysed. *Reflex paralysis*, however, often occurs after an injury or surgical operation, especially that for hæmorrhoids. The local *treatment* consists in the regular passage of an aseptic catheter two or three times daily.

Tubercle of the bladder is rare. It may be primary or secondary to tubercle in other parts of the genito-urinary tract, especially the testicle and prostate. It is most often met with in boys and young adult males. The tubercle which is deposited in the submucous tissue soon caseates, leading to small multiple circular ulcers with undermined edges. There is pain, hæmorrhage, irritability of the bladder and other signs of chronic cystitis; but the diagnosis will depend on the exclusion of other diseases such as stone, tumours, etc., and the presence of tubercle in other organs, and of the tubercle bacillus in the urine. With the cystoscope the ulcers may be seen. *Treatment.* — The general constitutional remedies for tubercle should be employed; together with such local remedies as are indicated for cystitis, and for the assuaging of the pain. Iodoform emulsion may be injected into the bladder or lactic acid up to 20 per cent. These failing to relieve, suprapubic cystotomy may be done and the bladder washed out, and such caseous masses of tubercle as permit of it scraped away.

Single simple ulcers have been discovered by the cystoscope and at the neck of the bladder cause a painful spasmodic fissure. As healing readily follows, tuberculous disease may be excluded. *Treatment.*—Applications and irrigations of nitrate of silver.

Vesico-intestinal fistula may be known by the occasional passage of fæcal matter and gas by the urethra, and is usually a source of great discomfort. It depends on inflammatory or malignant ulceration of the intestine involving the bladder, but may be due to the extension of malignant disease from the bladder. *Treatment.*—When the fistula is thought to be low down in the intestine the abdomen may be explored, and the colon above the fistula united to the abdominal wall and then opened, or if higher up an anastomosis may be made between the gut above and that below.

The tumours that may be met with in the bladder are:—1. *The fibrous.* 2. *The myxomatous.* 3. *The villous or papillomatous.* 4. *The malignant.* The *fibrous* and *myxomatous* spring from the submucous coat, and protruding the mucous membrane in front of them assume a polypoid or warty shape (Fig. 488). They are very rare. *The villous or papillomatous* spring from the mucous membrane and appear as soft, flocculent growths resembling the villi of

FIG. 488.—Myxomatous polypi of the bladder from a child two years old. The bladder has been everted and is almost completely occupied by partly sessile, partly stalked, transparent myxomatous polypi. Bristles are passed into the ureters which are dilated and thickened. The kidneys are hydronephrotic. (St. Bartholomew's Hospital Museum, No. 2147 a^1.)

the chorion. They may be single, as in Fig. 489, or multiple, studding the greater part of the bladder. They are the most common of the innocent growths. *The malignant* either spring from the mucous or the submucous coat, and may form a large mass nearly filling the bladder, or assume a villous appearance, or merely infiltrate the walls. They have either a carcinomatous or sarcomatous structure. *Cysts, hydatid* or *dermoid*, may communicate with the bladder. *Pelvic, abdominal, a psoas* or *hip-joint abscess*, also a suppurating *extra-uterine fœtation*, may rupture into the bladder.

The *symptoms* common to all tumours are those of a mass in the wall of the bladder, and absence on sounding of stone. In the *fibrous and myxomatous* there are signs of obstruction to the urinary outlet, pain and increased micturition, but little or no hæmaturia, and the tumour may sometimes be felt with the sound. In the *villous* (Fig. 489) there is at first intermittent but later more or less continuous hæmorrhage without any other cause being discoverable to account for it. The blood is of a bright red colour. There may be considerable irritability of the bladder, but there is seldom any marked obstruction to the urinary outflow. Shreds of the growth may come away spontaneously or in the eye of the catheter. In the *malignant* there are usually sudden attacks of severe hæmorrhage from time to time; and a growth may be felt by the sound, or by the finger in the rectum, or by palpation above the pubes. There are in the later stages, moreover, other signs of malignancy, such as rapid growth of the tumour, cachexia, ulceration into the rectum, enlargement of the lumbar glands, pain in the kidneys from obstruction of the ureters, and dissemination in internal organs. Obstruction to the urinary outlet may occur. Tumours of the bladder, however, especially the villous, are often difficult to diagnose; some aid, it is true, may be gained by the cystoscope, but a diagnosis cannot always be made without a digital exploration of the bladder, which should be undertaken early where symptoms such as the above are persistent, especially when they point to a malignant growth. If the urine contains much blood the patient should be kept at rest in bed before using the cystoscope till the hæmorrhage has ceased and fluid returns clear. Fragments of hydatid membrane, or fat and hair in the urine will indicate a communication with an hydatid or dermoid cyst, and pus may appear continuously or intermittently when an abscess has ruptured into the bladder.

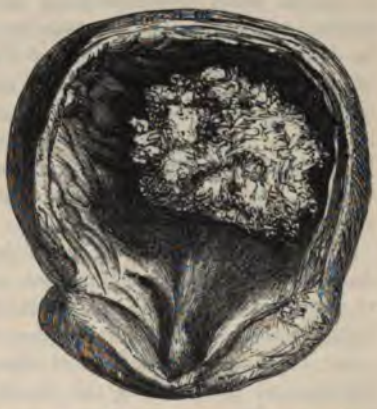


Fig. 489.—Villous tumour of the bladder. (St. Bartholomew's Hospital Museum.)

Treatment.—The removal of a tumour should generally be attempted by a suprapubic operation (see *Cystectomy*, p. 999). When on palpation a fixed, widely-infiltrating mass is discovered, suprapubic or perineal drainage, or the passage of a tube right through from one wound to the other and continuous irrigation may afford temporary relief. Cysts and abscesses should be reached, if

possible, by an extra-peritoneal incision, in the hypogastric or iliac region, the fingers pushing back the peritoneum and seeking for the cyst wall. When the peritoneal cavity has to be opened, general infection must be prevented by packing with sponges or gauze before proceeding to open the cyst or abscess.

Incontinence of urine or enuresis.—Involuntary escape of urine from the bladder may occur under several conditions. Thus —1. The urine may dribble away as fast as it enters the bladder, in consequence of paralysis of the sphincter vesicæ and inability to close the urinary outlet (*true incontinence*). 2. The urine may be passed involuntarily during sleep without any organic change in the urinary apparatus being discoverable (*nocturnal or active incontinence*). 3. The urine may constantly flow away, in consequence of the bladder being over-distended and capable of holding no more (*retention with incontinence*, or *false incontinence*). This last condition, which usually depends on obstruction to the outflow, will be described under *Retention of Urine* (p. 1028). The importance of recognising that it is of the nature of retention rather than of incontinence cannot be too strongly insisted upon. Whenever, therefore, an adult patient complains that he is unable to hold his water, or that it is continually dribbling away, an over-distended bladder should be suspected, the abdomen examined for such, and a catheter passed.

1. *True incontinence of urine* is very rare. *In males*, it may be due—(*a*) to a peculiar form of enlargement of the middle lobe of the prostate, whereby the urethra is rendered patent instead of being obstructed as is more commonly the case in enlarged prostate; (*b*) to a like patency of the urethra from the impaction of a calculus at the neck of the bladder or from a prostatic calculus; (*c*) to malformation (as a spina bifida), disease or injury of the spinal cord, implicating the lumbar enlargement, and inducing the bladder to become so contracted and thickened that it cannot hold any urine. *In females* it may be due—(*a*) to congenital patency or over-dilatation of the urethra, as in extracting a calculus from the bladder; (*b*) to prolapse of the mucous membrane through the urethra; or (*c*) to injury of the parts during parturition, causing a vesico-vaginal fistula. The *treatment* consists in removing the cause, or if this is impracticable, in rendering the patient's condition as comfortable as possible under the circumstances by a urinary convenience.

2. *Nocturnal or active incontinence* generally occurs in children, especially boys, and must be distinguished from the involuntary passage of urine which is an occasional symptom of thread-worms, calculus, long prepuce, or growth in the bladder. In nocturnal incontinence proper, beyond that the child wets his bed, no sign of disease of any kind is discoverable. *Treatment.*—Presupposing that the absence of thread-worms, calculus, long prepuce, and

growth in the bladder has been ascertained, the treatment should consist in tonics, cold baths, and the administration of belladonna in increasing doses till symptoms of belladonna-poisoning appear. The child should be made to lie on his side, not on his back, by fixing a block of wood, for example, over the lumbar spine at night, and he should be awakened at regular intervals to pass water. We have found the continuous galvanic current of service, one pole applied over the urinary centre in the lumbar region, the other to the perineum. In obstinate cases, Sir Henry Thompson advises the application of a solution of silver nitrate (gr. x. to ℥j.) to the neck of the bladder.

Hæmaturia, or bloody urine, is generally a symptom of disease or injury of the urinary organs, but may also occur in certain constitutional conditions, as scurvy, acute rickets, purpura, malaria, the hæmorrhagic diathesis, and in some fevers. When blood is present in large quantities, the urine is bright red or coffee- or porter-coloured; when in smaller quantities, of various shades of brown to which the term "smoky" is applied. Blood may be simulated by urates, indican, bile, or rhubarb or other colouring matter which may have been introduced by impostors. The dark greenish colour of the urine which is produced by the absorption of carbolic acid from a wound must not be mistaken for blood. Blood may be distinguished by blood-globules being seen under the microscope, by the spectroscope, or by the ozonic ether test. Add a few drops of tincture of guaiacum to the suspected urine, and then an excess of ozonic ether, shake the mixture and allow it to stand; it will assume a blue colour if blood is present. The same reaction occurs if the patient is taking potassium iodide. Albumen will be detected in the urine if blood is present in quantity. For *Hæmatinuria*, see a work on Medicine.

Source of the blood.—The blood may come from—1, the kidney or ureter; 2, the bladder or prostate; or, 3, the urethra. *When from the kidney or ureter* it may be due to (*a*) injury, (*b*) congestion or inflammation, (*c*) Bright's disease, (*d*) the administration of turpentine or the application of a cantharides blister, (*e*) the presence of a parasite, the *Bilharzia hæmatobia* (p. 115), in the pelvis of the kidney in persons who have been in Africa, (*f*) the impaction or passage of a calculus, (*g*) tubercle, (*h*) the passing of a catheter up the ureter, or (*i*) malignant disease. *When from the bladder or prostate* it may be due to (*a*) injury, including catheterism, (*b*) calculus, (*c*) cystitis or prostatitis, (*d*) tubercle, or (*e*) villous or malignant growths. *When from the urethra* it may be due to (*a*) injury, (*b*) gonorrhœa or chancre, (*c*) erectile growths, (*d*) calculus, (*e*) rupture of corpus spongiosum in chordee or sexual intercourse.

Diagnosis.—Blood from the *urethra* comes before the urine, is frequently pure, and may continue flowing between the acts of micturition. From the *bladder or prostate*, it generally comes

after the urine, or the urine contains more blood at the end than at the beginning of micturition; it is often clotted from remaining some time in the bladder, and the urine then is of a porter-like colour. From the *kidney* it comes with the urine, with which it is intimately mixed (*smoky urine*). The urine may then contain blood-casts of the renal tubes, or when it comes from the *ureter*, fibrinous casts of the ureter.

The *treatment* resolves itself into remedying where possible the cause (see *Diseases of Kidney, Bladder*, etc.). When clots have collected in the bladder, they may be allowed to dissolve spontaneously or be washed out with an evacuator and a stream of warm water; but when they are decomposing, it may be necessary to open the bladder through the perineum or above the pubes and remove them.

Chyluria is usually endemic in origin (see *Filariasis*, p. 113), but occasionally occurs after a strain, or in women during pregnancy from unexplained causes. It may come on suddenly; it may pass off or persist, or recur when a fulness or dragging in the pelvic organs may be noted beforehand. The urine when passed has a milky appearance with a pinkish tinge. On standing it generally undergoes rapid spontaneous coagulation, separating into three layers, the uppermost whitish and fatty, the lowest reddish formed by blood débris, and the middle layer consisting of pinkish-red fibrin. Filarial embryos are mainly found in the sediment, derived from parent worms in the thoracic duct. The urine contains a large amount of albumen. The chyluria may spontaneously cease; if not the patient may gradually become exhausted and develop amyloid disease. Chylous hydrocele, peritoneal or pleural exudation of chyle, or elephantiasis may accompany the chyluria.

Foreign bodies in bladder (see *Injuries of the Bladder*, pp. 561, 563).

Stone in the bladder may occur at any age, but is said to be most frequent between the ages of fifty and seventy; next, between the ages of two and six; whilst, between the ages of twenty-six and thirty-six it is rare. It may occur in both males and females, but is decidedly more common in the former. It is most frequently met with, where not endemic, in the children of the poor and in old men of the upper classes with more or less enlargement of the prostate and of gouty habit.

The *causes* are but little known, but (1) residence in certain districts or countries, as around Norwich and in the North-West Provinces of India, and (2) derangements of digestion leading to an excess of urates in the urine as from (*a*) improper feeding or poor living, as evidenced by the former frequency of stone in the children of the poor, (*b*) the abuse of alcohol especially in the form of malt liquor, (*c*) excess of nitrogenous food, (*d*) want of sufficient exercise, etc., are regarded as predisposing causes. Retention of urine from

prostatic enlargement, the small size of the urinary passages in male children, and the presence of a foreign body in the bladder are exciting causes. The causes of oxaluria and of cystinuria and the consequent formation of the oxalate of lime and the cystine calculus are quite unknown. In a few cases a nucleus has been formed for a calculus by a piece of necrosed bone which has reached the bladder from a fractured pelvis or carious spine.

Varieties.—The three most common varieties of calculi met with in the bladder are the uric acid, the oxalate of lime, and the phosphatic. They may occur almost pure or they may be mixed. According to Sir Henry Thompson the uric acid and urates form one half of the number met with; the phosphatic one quarter; the mixed one quarter; and the oxalates only 3 per cent. of the whole. The uric acid and the oxalate of lime are generally formed on a nucleus of one of these substances which has descended from the kidney. The phosphatic is formed in the bladder itself, either on a nucleus of phosphates deposited on some inspissated mucus or a foreign body, or on one of the other forms of stone which has descended from the kidney and which sooner or later acts as a foreign body. The oxalate of lime is the most slow of formation and is consequently the hardest and most compact. The phosphatic forms very rapidly, is soft and friable, and often of very large size. Sometimes alternate layers of uric acid, oxalate of lime, and phosphates occur in the same stone (*alternating calculus*), a condition probably due to varying states of the patient's health, effects of medicines, bladder irritation, etc. A description of the various forms of calculi is given in the section on *Urinary Calculi* (p. 970).

The *character* of the stone may to some extent be guessed at by the state of the urine. Thus if the urine is acid it will probably be either oxalate of lime or uric acid; if alkaline, phosphatic. Calculi vary in size from that of a hemp-seed to a large mass weighing many ounces; but large stones, at the present day, in consequence of improved diagnosis, and the diminished dread a patient has of an operation, are the exception. They generally occur singly, but there may be two, or even more; they are then usually facetted from rubbing against one another.

Spontaneous fracture sometimes happens, and has been attributed —1, to the swelling or chemical alteration of the cementing material with which the particles of the calculus are held together; 2, to two stones coming into collision; 3, to the compression of the calculi by the hypertrophied muscular coat of the bladder.

The calculus is usually free just behind the prostate, but it may be in the upper fundus behind the pubes, or in one of the sacculi so often found in long-standing disease of the bladder (encysted), in a patent urachus, or in an inguinal hernia. Calculous matter may sometimes be deposited upon growths in the bladder or upon the ulcerated mucous membrane.

The *terminations of stone.*—If neglected, cystitis is set up, and inflammation may spread up the ureters to the kidneys, leading to interstitial nephritis, multiple abscesses, pyonephrosis, and in the end suppression of urine. In consequence, moreover, of the obstruction of the urinary outlet, the bladder may become hypertrophied, and the ureters and kidneys dilated in the way described under *Stricture.*

Spontaneous escape of a stone.—This may take place by the urethra, or by ulceration from the membranous urethra through the perineum, or rarely from a prostatic pouch into the rectum, or from a sacculus into the peritoneal cavity and set up septic peritonitis.

Symptoms.—The three chief symptoms are—1. Pain, generally referred to the end of the penis, and worse after micturition on account of the stone then falling on the sensitive trigone and the walls of the bladder contracting upon it. 2. Frequent micturition; and, 3. A little blood in the urine. These symptoms are increased on exercise, especially riding, and after the jolting of a railway journey, etc., and are least marked at night when the patient is at rest. Other symptoms that may be present are the passage of gravel; sudden stoppage of the stream during micturition; the

Fig. 490.—Ordinary sound.

presence of muco-pus in the urine owing to cystitis; piles in adults and prolapse of the rectum in children, due to straining; and elongation of the prepuce in boys caused by the constant pulling to relieve pain after micturition. Stone in the bladder may be simulated by cystitis, an enlarged prostate, a long or adherent prepuce, a narrow meatus, a growth in the bladder, calculous or other disease of the kidney, a peculiar choreic condition of the bladder (the stammering bladder, as it was called by Sir James Paget), tubercle of the bladder, and ascarides in the rectum. An accurate diagnosis, however, can be made only by sounding the bladder; though in boys the stone may be felt by the finger in the rectum whilst pressure is made with the other hand above the pubes.

Sounding the bladder.—The ordinary sound (Fig. 490) is a solid steel instrument with a short bulbous beak. Thompson's sound is hollow to allow some of the urine to be drawn off if desired, and has a handle like that of his lithotrite, to facilitate the necessary movements in the bladder. Having warmed the sound and lubricated it with glycerine, pass it like a catheter, letting it glide into the bladder by its own weight without using any force. When the sound is in, gently push it onwards to examine the posterior part of the bladder. Then turn the beak alternately to either

side; and depress the handle between the patient's thighs to search the upper fundus. Then turn the beak downwards to examine the base or lower fundus. If the stone is not detected, let out a little of the urine, or change the patient's position, or raise his pelvis and try again. The stone may not be felt, because it is of so small a size, or has become encysted, or entangled in a fold of mucous membrane. A guarded opinion, therefore, should be given, and a further examination made another day. A stone may be known to be present by the peculiar ring which is both felt and heard on striking it. This ring is quite unlike the sensation given to the sound by its coming into contact with phosphatic deposits on a roughened or fasciculated bladder, or with a growth, or with one of the pelvic bones. Having discovered a stone, the next care should be to determine approximately—1, its probable size and composition; 2, whether it is free or encysted; 3, whether there is one stone or more; and, 4, the condition of the bladder and urethra. 1. The *size of the stone* can be roughly estimated by the amount of resistance offered on pushing it before the sound or by passing the sound over it, and by feeling it through the rectum with the other hand pressing on the hypogastrium. Its exact size can only be ascertained by seizing it with the lithotrite, the distance the blades are then apart being indicated by the scale on the handle. The *composition of the stone* may be approximately arrived at by (*a*) the character of the ring on striking it—the clearer the ring the harder the stone, (*b*) the condition of the surface, which is rough in the oxalate of lime and smooth in the phosphatic, (*c*) the reaction of the urine, and (*d*) the general health of the patient. 2. A *stone, when encysted*, is always felt at the same spot in the bladder, generally near the trigone, and when seized with the lithotrite cannot be moved. The sound cannot be passed all round it. There is no blood present, and the symptoms are usually less severe, and are not increased by exercise. 3. The *presence of a second stone* can only be determined with certainty by seizing one stone with the lithotrite, and then striking the other. *X* ray examination has hitherto been somewhat uncertain, partly owing to the intervention of the pelvic bones.

Treatment.—The stone may be removed by crushing (*lithotrity*), or cutting (*lithotomy*). In adults, lithotrity, with but few exceptions, should be the rule. In children, up to twelve or fourteen years of age, lithotomy was formerly the recognised operation; but since the brilliant results obtained by Colonel Keegan and others even in very young children, lithotrity, as in adults, should be the rule, lithotomy the exception. Walsham has crushed stones in young male children, some as young as three years, and successful cases are now frequently reported. In adults suprapubic lithotomy should be practised in place of lithotrity, 1, when the stone is very large and hard; 2, when the urethra is the seat of intractable

stricture; 3, when the stone is encysted; and, 4, when the bladder is sacculated. A large stone, if soft, should be crushed; and a hard stone, if not too large, is no bar to the operation. Colonel Keegan has crushed a uric acid stone, the fragments of which weighed two ounces and three quarters, and an oxalate of lime which weighed one ounce and three drachms. And in a boy, aged thirteen, Walsham crushed and successfully removed a very hard stone weighing only a few grains less than an ounce. Hard stones, however, weighing above an ounce, and especially in boys, had better be removed by suprapubic lithotomy, unless the surgeon is experienced in lithotrity. Cystitis and kidney disease render the prognosis of both operations unfavourable; but in these affections it does not appear that crushing, with complete removal of the fragments, is attended with more risk than is lithotomy. A large prostate renders lithotrity difficult no doubt, but does not, as a rule, contra-indicate it. Stricture of the urethra is only an impediment to lithotrity when the stricture cannot be dilated. The conditions, however, most favourable for success in lithotrity are, as well expressed by Sir Henry Thompson, "a capacious urethra, a bladder capable of retaining three or four ounces of urine, absence of ordinary signs of renal disease, and fair general health."

Calculus in the female bladder is much less common than in the male, a fact in great part due to the shorter and more dilatable urethra in women, to the absence of a prostate and consequent exemption of the female from chronic retention and phosphatic deposits, except from the latter forming round a foreign body. The symptoms are similar to those in the male, but are sometimes apt to be accompanied by incontinence of urine. They may, at times, be simulated by vascular growths in the urethra, by uterine disease, and by hysteria.

Treatment.—1. When the stone is small rapid dilatation of the urethra with the finger or with the three-bladed dilator or dressing forceps is the best method of extraction. 2. When of larger size (above three-quarters of an inch in children and one inch in adults), lithotrity with removal of the fragments at one sitting should be done. 3. When too large for removal by dilatation, and the bladder is too contracted to allow of crushing, the suprapubic operation is called for.

Slow dilatation, dilatation with incision (*urethral lithotomy*), and incision through the vagina (*vaginal lithotomy*) are very liable to be followed by incontinence of urine, especially in children.

Operations on the bladder.

Lithotrity, Litholapaxy, or **Bigelow's operation** consists in crushing the stone in the bladder, and removing the *whole* of the fragments through a large evacuating catheter. Formerly, it was

taught that the presence of the lithotrite in the bladder for more than a few minutes at a time was productive of great irritation, and it was consequently advised that the crushing of the stone should be extended over several sittings of only a few minutes each, and the fragments allowed to be passed by the natural efforts of the patient. To the late Prof. Bigelow is undoubtedly due the credit of having enunciated the principle that the bladder is not so intolerant of instruments, as was formerly supposed, and that it was to the presence of the fragments, rather than to the lithotrite, that the irritation, cystitis, etc., so common after the old method, should be ascribed.

The operation.—The patient, having been prepared for the operation by careful attention to the general health, rest, and such local means for allaying chronic cystitis as are pointed out under that head, should be placed under an anæsthetic, with the pelvis raised a few inches, the thighs slightly apart, the knees supported on a pillow, and the body and legs well wrapped up in blankets to avoid a chill. The rectum should be emptied by a purge the day before, and by an enema on the morning of the operation. A few ounces of urine in the bladder is desirable. If necessary, incise the meatus

Fig. 491.—Thompson's lithotrite.

(a stricture, if present, should have previously been dilated), warm and oil the lithotrite (Fig. 491), and pass it with all gentleness, letting it glide by its own weight through the spongy and membraneous portion of the urethra, and do not depress the handle till the blades have reached the prostate. Then bring the shaft to an angle of 35 degrees with the horizon, and it will glide through the prostatic urethra, over the trigone of the bladder, and may possibly be felt to graze the stone. The blades now rest in the lower part of the bladder and point upwards (Fig. 492). Hold the handle tightly with the left hand, and, without moving the instrument, open the male blade by drawing out the wheel-shaped end with the right hand. Pause a few seconds to allow the currents set up in the urine by this movement to subside. Then gently press in the male blade, and the stone will probably be caught. If so, continue the pressure on the wheel to retain the stone between the blades, whilst the button is moved by the thumb to convert the sliding into the screw movement. Rotate the instrument slightly to make sure that the mucous membrane is not caught by the blades; slightly depress the handle to raise the blades from the wall of the bladder, and screw home. The stone will probably be felt to crack and break into fragments. If the stone cannot be seized in this

way, systematically explore the bladder thus:—Open the blades and rotate 45 degrees; pause and close. Do this first to the right, then to the left. Then raise the blades slightly by depressing the handle; rotate alternately to right and left 90 degrees; further raise the blades and rotate 135 degrees. Finally, reverse the blades by rotating half a circle. In this way the stone will probably be found. In these manœuvres the blades should be opened before rotating them in order that the stone may not be displaced by the male blade, and, after rotating, a pause should be made before closing them to allow the currents to subside. Having crushed the stone and larger fragments, withdraw the lithotrite, first screwing tight home to ensure complete closure of the blades

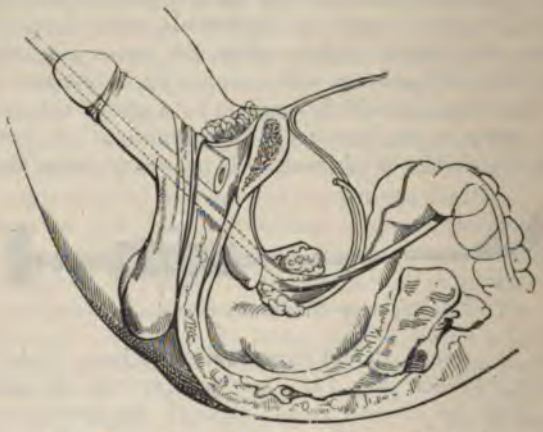


Fig. 492.—Lithotrite *in situ*. (Liston's Surgery.)

in order to prevent laceration of the urethra. Next introduce a large evacuating catheter (No. 10 (English gauge), or larger); let all the urine escape and inject two or three ounces of warm water. Attach the aspirator, previously filled with water at a temperature of 98 degrees, and compress the india-rubber bulb, driving some of the water into the bladder. Let the bulb expand and the outward current will bring away some of the fragments and *debris* which will fall into the receiver and be prevented from running back into the bladder by the trap (see Fig. 493) on again compressing the bulb. Continue compressing and relaxing till fragments cease to come away. Then, if any are felt by the evacuating catheter, reintroduce the lithotrite, or a smaller one, and crush again and aspirate as before, repeating this *till all the fragments are removed*. The operation frequently lasts for an hour to an hour and a half or longer.

After-treatment.—Opium, if no serious kidney disease is present, may be given; and hot hip-baths if there is much pain. If there

is retention the catheter should be used at regular times, or tied in if its passage causes much irritation and pain. Complete rest in bed for a few days or longer should be enjoined. If cystitis follows the operation, Sir Henry Thompson strongly recommends a weak injection of silver nitrate (gr. i. to f ʒ i). As a rule, however, no after-treatment is required, even in young boys. Indeed in several cases the child has been up and playing about the day after the operation.

After-complications.—1, Rigors and fever, 2, retention of urine, 3, acute cystitis, 4, prostatitis and abscess, and 5, orchitis and epididymitis, occasionally occur. More rarely, 6, hæmorrhage, 7, suppression of urine, and 8, phlebitis of the prostatic plexus of veins, followed by pyæmia. The impaction of a fragment of the calculus in the urethra (formerly common when the fragments were left in the bladder) cannot occur if the bladder has been thoroughly evacuated.

Causes of death.—Death may occur from 1. Acute nephritis; 2. Pyelitis; 3. Cystitis; 4. Perforation or rupture of the bladder; 5. Peritonitis; 6. Sapræmia or pyæmia; or 7. Exhaustion. But a fatal termination is rare except when there is some chronic kidney disease.

Fig. 493.—Thompson's improved evacuator and trap.

Lithotomy, or "cutting for the stone," may be performed through *the perineum* or above *the pubes.* Perineal lithotomy may be done in many ways; the lateral, as formerly performed, and the median will only be described.

Lateral lithotomy.—This operation is now very rarely performed. The patient should be prepared by rest in bed for a few days, and the rectum cleared by a mild purgative the day before, and by an enema on the morning of the operation. The bladder should contain five or six ounces of urine, or if the patient is unable to retain so much, an equal quantity of warm water should be injected. Anæsthetise the patient, introduce a full-sized staff with a groove on the left side into the bladder, and try to strike the stone. If the stone is not felt, withdraw the staff and pass a sound. If still unsuccessful, send the patient back to bed as the stone may have been passed per urethram or become encysted. If felt by the sound, reintroduce the staff, but do *not* operate until the staff itself strikes the stone, that you may be sure that the staff has passed into the bladder, and not into a false passage. It is the rule to ask an assistant to strike the stone also. Next, place the patient in the lithotomy position, *i.e.*, with the soles of the feet secured in the palms of the hands by the lithotomy shackles, and bring his nates well over the end of the table.

Entrust the staff to an assistant, who should hold it perpendicularly with its concavity hooked well up under the pubes and exactly in the middle line. Seat yourself in front of the patient, and having introduced the left forefinger into the rectum to make sure that it is empty, and to induce it to contract, enter the knife (Fig. 494), which should be held horizontally, a little to the left of the middle line, and about an inch and a quarter in front of the verge of the

Fig. 494.—Lithotomy knife.

anus, and carry the incision downwards and to the left to a point one-third nearer to the tuberosity of the ischium than to the margin of the anus. Pass the left forefinger into the upper angle of the wound and feel for the staff; divide with the knife the superimposed tissues; insert the finger-nail into the groove in the staff, the back of the finger being to the patient's left; and, guided by the nail, press the point of the knife into the groove just in front of the membranous portion of the urethra (Fig. 495). Now run the

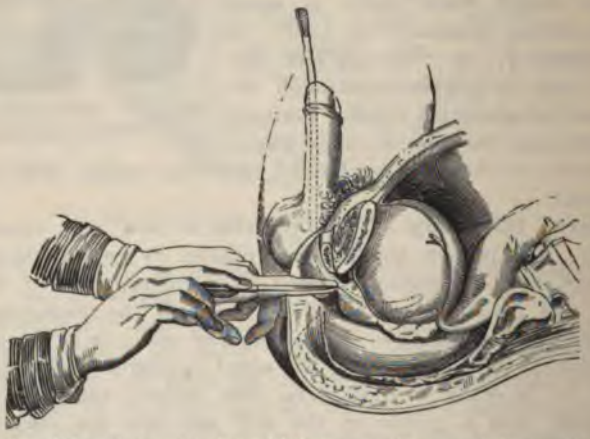


Fig. 495.—Parts cut in lateral lithotomy. (Fergusson's Surgery.)

knife, with the point placed firmly in the groove, onwards into the bladder, keeping its blade well lateralised, *i.e.*, directed downwards and to the left. Take care not to depress the handle too much for fear of cutting the prostate too widely, nor to hold it too horizontal lest the point slip out of the groove and penetrate the tissues between the bladder and the rectum. Having entered the bladder, slightly enlarge the wound in the prostate in withdrawing the knife, and pass the left forefinger, which is in the wound,

onwards along the staff into the bladder. If the stone is felt by the finger ask the assistant to withdraw the staff. Take the forceps in the right hand, pass them along the left forefinger towards the bladder, and, on withdrawing the finger, open the blades, and the stone will probably be driven by the gush of urine between them. Having assured yourself that the stone is grasped by the forceps in the smallest diameter, extract it by making traction downwards and backwards in the axis of the pelvic outlet. Reintroduce the finger into the bladder to ascertain whether there may not be another stone, and if in doubt use the searcher. Inject two or three syringefuls of cold water into the bladder; dust the wound with iodoform; apply no dressings; tie the legs together if the patient is a child, and send him back to bed as quickly as possible. If there is hæmorrhage, tie any bleeding point which is seen, or if the blood comes from the deep part of the wound, introduce the petticoated tube (Fig. 496), assuring yourself that the end is in the bladder by injecting water and passing a probe through it. Then plug firmly round with strips of lint between the petticoat and the tube. The petticoated tube should not be used unless absolutely necessary.

Fig. 496.—Petticoated tube.

At Guy's Hospital lateral lithotomy was performed on a straight staff, by the operation known as Key's. A good description of the method will be found in Bryant's Surgery.

The *structures divided in the operation* are:—1, the skin; 2, the superficial and deep fascia; 3, a few branches of the external hæmorrhoidal vessels and nerves; 4, the transversus perinei muscle, vessels and nerve; 5, a few fibres of the accelerator urine and levator ani muscles; 6, the compressor urethræ muscle; 7, the membranous portion of the urethra; and 8, the prostate.

The dangers of the operation are:—A. *Before the point of the knife has entered the groove in the staff*—1, wounding the rectum, either from cutting too perpendicularly, or from not having had it cleared out by an enema; 2, wounding the artery of the bulb in consequence of beginning the incision too high, or directing the point of the knife subsequently too much upwards; and 3, missing the groove in the staff. B. *On entering the bladder*—1, letting the point of the knife slip out of the groove in the staff and enter the cellular tissue between the bladder and rectum; 2, cutting the pubic artery from holding the knife too much lateralised; 3, sending

the point of the knife through the posterior wall of the bladder; 4, cutting the prostate too widely, and dividing its sheath, whereby the urine may be extravasated into the cellular tissue of the pelvis; 5, wounding the prostatic plexus of veins; 6, tearing the urethra across, and so pushing the bladder off the end of the staff, whilst trying to pass the finger into the bladder (this accident is due to not making the opening into the urethra large enough, and is most common in children in whom the tissues are readily lacerable); 7, making too small an incision in the prostate, so that the parts are bruised or torn in removing the stone, and inflammation is set up; 8, seizing the walls of the bladder by the forceps. ***These dangers may be best avoided by observing the following rules***—1, feel the stone with the *staff* before you begin the operation; 2, see that the rectum is empty, and make it contract by introducing the finger; 3, make the external incision free; 4, feel *both* edges of the groove in the staff with the finger, and place the point of the knife ***between*** them; 5, keep the point of the knife well pressed into the groove of the staff; 6, take care that the finger is pushed into the bladder in *contact* with the naked staff; 7, do not remove the staff till the finger touches the stone.

The difficulties of the operation.—In adults the chief difficulty is to extract the stone; in children to get the finger into the bladder. A. *The difficulty in entering the bladder* depends chiefly on—1, not making the opening into the urethra free enough, and so pushing the finger between the bladder and the rectum; 2, a deep perineum so that the finger cannot reach the bladder; in such case a blunt gorget must be substituted for the finger. B. *The difficulties in extracting the stone* are—1, the stone may be too large: 2, it may get behind the prostate; 3, it may be lodged in a pouch in the upper fundus; 4, it may be encysted; 5, it may break or crumble up; 6, it may be so small that it slips from between the blades of the forceps; 7, there may be an enlargement of, or tumour in, the prostate, whereby the urethra is greatly lengthened; 8, there may be some rickety or other deformity of the pelvic bones. When the stone is behind the prostate, curved forceps with the blades turned down must be used; when the stone is above the pubes, the blades must be turned upwards, the handle depressed, and the stone pressed down by the hand above the pubes. When too small to be seized, the scoop must be substituted for the forceps. If the stone breaks, the fragments must be removed by aid of the scoop and syringe. If encysted, it may be scratched out with the finger-nail, or freed with a probe-pointed bistoury. If too large to be extracted, the wound should first be slightly enlarged; or, this being insufficient, three expedients remain—1, to make an incision in the opposite side of the prostate; 2, to crush the stone; 3, to do the suprapubic operation. To overcome the difficulty of an enlarged prostate, the blunt gorget (Fig. 513, p. 1024) must be used and the

forceps slid along it. A fibrous tumour in the prostate may be previously shelled out. Where the pelvic outlet is too small to allow of extraction, suprapubic lithotomy must be done.

Causes of death after lithotomy.—1. Diffuse septic inflammation of the cellular tissue of the pelvis due either to infiltration of the urine from too free cutting, or to bruising of the parts in extracting a large stone through a small incision; 2, peritonitis due to the spread of the inflammation to the peritoneum, or to a wound of the back of the bladder; 3, shock from too prolonged an operation; 4, exhaustion from primary or secondary hæmorrhage; 5, blood-poisoning, due to the absorption of the products of putrefaction (sapræmia), or to septic phlebitis of the prostatic plexus of veins and pyæmia; 6, cystitis; and 7, suppression of urine. The state of the kidneys is of the most serious import. Where these are healthy, as in children, lateral lithotomy is most successful; but in adults, in whom grave kidney mischief often exists, it is liable to be followed by one or more of the above complications, especially diffuse pelvic inflammation. Thus, in boys, when death occurs it is generally the result of some one of the accidents liable to occur during the operation; in adults the cause is usually dependent primarily on kidney mischief.

The *after-treatment* is very simple, and consists in little more than keeping the patient clean, and in regulating the secretions and diet. Adults may be placed on a mattress, with a hole opposite the perineum, for the purpose of letting the urine drain through. During the first few hours it is essential to see that the wound is free. Should the urine not escape from it, it is probably plugged with a clot of blood; the finger must then be passed into the wound, or if a tube has been introduced, this must be cleared by a probe or feather, or by syringing. From the third to the fifth day, in consequence of inflammatory swelling, more or less of the urine is passed by the urethra, but as this swelling subsides, the greater part may again pass by the wound; more, however, is gradually passed by the natural way and less by the wound, as the latter slowly heals. Should secondary hæmorrhage occur, the wound must be plugged; or if this fails to arrest it, perchloride of iron or the actual cautery must be used. For the treatment of the other complications see *Cellulitis*, *Peritonitis*, *etc.*

Objections to lateral lithotomy.—To summarise the reasons for the disuse of lateral lithotomy, the stone is only reached by tearing and cutting in the depth of a wound, which favours septic absorption and hæmorrhage, which cannot be arrested by ligature, and further tearing to an uncertain extent is required for the removal of any but small stones. A fistula may persist or sterility be caused by cutting across the seminal ducts.

Median cystotomy and lithotomy.—Pass a staff, grooved on its convexity, into the bladder, and, with the left forefinger in the

rectum, feel for the apex of the prostate. Make an incision with a straight bistoury, with its back towards the rectum, in the median line of the perineum, beginning about half an inch in front of the anus. Insert the point of the knife into the groove of the staff just in front of the prostate, notching the apex, and cut a little upwards, opening the membranous portion of the urethra. Withdraw the knife, slightly enlarging the external incision upwards if necessary, and pass a long bulbous probe along the groove of the staff into the bladder. Withdraw the staff, and gently work the forefinger into the bladder, or pass the gorget along the probe, thus dilating the prostate. Extract the stone in the usual way. The operation is suitable—1. For small stones or foreign bodies; 2. When it is important that there should be little loss of blood; 3. For the removal of small growths; and 4. For exploring the bladder in doubtful cases of disease. All the cutting is done entirely in the median line where no vessels exist; the deeper parts of the wound are merely dilated, not cut. Median lithotomy may be combined with lithotrity through the wound (*perineal lithotrity*), a straight lithotrite being then used. The operation is rendered more efficient by employing a superficial transverse semilunar incision, retracting and clamping vessels, then cutting into the urethra longitudinally, exactly in the middle line (see p. 1006).

Suprapubic cystotomy and lithotomy consists in opening the bladder between the pubes and the peritoneal fold. It is the method that should be employed for the removal of very large stones, encysted stones, and for tumours of the bladder and prostate or intractable stricture of the urethra. It should *not* be performed where the bladder is greatly contracted. The bladder having been washed out with warm boric-acid lotion, some pass a Petersen's indiarubber bag into the rectum and moderately dilate it with air or insert a sponge; next slowly and gently distend the bladder with air or boric-acid lotion till it rises well into the abdomen and appears as a prominent tumour above the pubes. Prevent the escape of the lotion or air by tying a piece of rubber tube round the penis. Make an incision in the middle line immediately above the symphysis (Fig. 407, B), and having divided the tissues forming the linea alba, expose the wall of the bladder by gently separating the fatty tissue that lies in front of it with the finger or director, avoiding the peritoneal fold, and, if possible, the large veins which ramify in this situation. Now raise the pelvis, and the bladder having been fixed by inserting a sharp hook into its walls, make an incision into it; introduce the finger to ascertain the size of the stone; enlarge the wound, if necessary, by cutting towards the pubes, and extract the stone with the finger and scoop, or with the forceps. If the stone is encysted it may be removed with the scoop, aided by slightly notching the margins of the aperture of the cyst with a hernia knife, or the stone may be extruded from the cyst by pressure with the finger in

the rectum, a rubber glove being put on for this purpose. If the stone is very large and cannot be broken by a hammer and chisel, the peritoneal cavity may be freely opened and guarded with sponges, after which the bladder can be laid widely open. The site of the tumour may be lighted up by passing a large silvered-glass vaginal speculum into the bladder so that the tumour may lie included in its lumen. If more light is required a small electric lamp on a slender handle can be passed down the speculum. Villous papillomata and polypi involving the mucous membrane only may then be removed by the cold wire or galvano-cautery loop, or by forceps, or be burned off with the actual or galvano-cautery. If a villous tumour is simply torn off by forceps, severe hæmorrhage, which may prove uncontrollable and end fatally, may ensue. If the base of a polypoid growth is left, recurrence soon takes place. Hence partial cystectomy is much better.

Cystectomy.—1. *Partial cystectomy.*—The bladder being opened and the tumour drawn forwards from within, the mucous membrane well beyond the growth is cut round with scissors and the tumour removed with as much of the muscular wall as seems affected, after which sutures are inserted from within the bladder by some convenient needle, such as are used for cleft palate, through the mucous and muscular coats which are then drawn together, and the wound in the bladder wall thus closed. Or the peritoneum is stripped off until the base of the tumour is reached, when the whole thickness of the bladder wall is excised so as to include the base of the tumour, after which the gap is united by inserting sutures from without as described on p. 557. A malignant growth must be treated in this way.

2. *Complete cystectomy* is performed by stripping off the peritoneum or by opening the peritoneal cavity and protecting the intestines by sponges. The ureters, and also the trigone around their orifices, if free from disease, are raised and inserted into the sigmoid flexure or rectum, and the remainder of the bladder up to the sphincter dissected out. After arresting hæmorrhage the peritoneal cavity is closed. If the trigone is involved the ureters must be divided above the bladder and inserted into the sigmoid ; but there is then more likelihood of regurgitation up to the kidney of septic material.

The raised pelvis or Trendelenburg's position is of good service in preventing the intestines from bulging forwards, and in affording a better view.

After removal of a stone or tumour, the bladder is first closed and all hæmorrhage arrested. If the peritoneal cavity has been opened, it must be carefully sutured after removing the sponges or gauze protecting the intestines. Then the upper part of the wound in the abdominal parietes is closed, and a strip of gauze inserted behind the pubes, for the wound has been soiled with urine, and thus cannot be rendered aseptic, and urine may leak, so that were the

skin entirely sutured suppuration and extravasation into the prevesical tissue would be likely. A catheter may be passed every four hours, or be tied in and connected with a tube emptying into a vessel under the bed, which will also serve to irrigate the bladder at any time. Or it may be thought best to drain above the pubes as described on p. 978.

DISEASES OF THE PROSTATE.

Acute prostatitis.—*Causes.*—Generally, gonorrhœa, or stricture of the urethra; less frequently cystitis, impacted calculus, and passage of instruments. Occasionally in gouty subjects, it appears to occur idiopathically. *Symptoms.*—Micturition is frequent, and attended with pain, especially at the end of the act; there is throbbing and continuous pain in the perineum and neck of the bladder, and pain during defæcation. When examined by the finger in the rectum, the prostate is found hot, swollen, and tender, and the passage of a catheter causes great pain. The febrile disturbance which accompanies it is perhaps ushered in by rigors. *Terminations.*—Resolution, abscess, or chronic inflammation. *Treatment.*—Six or more leeches to the perineum; hot hip-baths; hot boric poultices to the perineum; morphia suppositories; and a purgative at the onset, followed by alkaline medicines. A catheter is to be passed only if there is retention of urine.

Abscess of the prostate is generally preceded by acute inflammation; but chronic abscess may be produced by catheterism in chronic enlargement of the organ. Acute abscess may be suspected, when, in the course of acute prostatitis, rigors and retention of urine supervene. Fluctuation can at times be felt through the rectum, but the abscess is generally first discovered on passing a catheter for the relief of the retention of urine, when a quantity of pus escapes from the urethra. At times the abscess may burst into the rectum or perineum and give rise to a sinus. *Treatment.*—An incision in the middle line of the perineum, or in some cases through the rectum, to let out the pus. When the pus forms around the prostate instead of in its substance, a *periprostatic* abscess is said to have occurred. The cause, symptoms, and treatment are similar.

Chronic prostatitis generally occurs as a sequel to the acute. The symptoms are similar but of much less intensity; and there is a glairy discharge with, sometimes, a drop or two of blood in it. The urine is cloudy and contains pus and prostatic casts. Nocturnal emissions are frequent. If the inflammation is not relieved, cystitis may follow, and the bodily and mental health become seriously impaired. *Treatment* is unsatisfactory: blisters to the perineum; belladonna suppositories; the occasional passage of a bougie; gentle laxatives; tonics, especially iron; iodide of potassium; change of air or a sea voyage; sea-bathing; a generous diet; and the avoidance

of stimulants, horse-exercise and sexual indulgence. The application of silver nitrate to the prostatic urethra is recommended by some surgeons when there are nocturnal emissions.

Senile hypertrophy or enlargement of the prostate.—This condition should be clearly distinguished from enlargements due to inflammation.

Pathology.—Writers on the subject differ very widely, but considerable information has been recently obtained in the performance of prostatectomy. It has been known from ancient times that in the course of perineal lithotomy small tumours like marbles may be shelled out from the prostate. McGill, of Leeds, commenced the

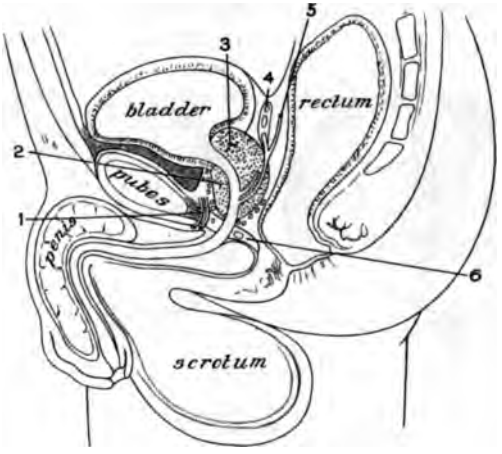


Fig. 497.—Anatomical relations of an enlarged prostate. 1. The prostatic sheath formed by the recto-vesical fascia, in which are large veins. 2. The portion of the prostate lying in front of the urethra. 3. The prostate behind and above the urethra. 4. Vesicula seminalis. 5. Vas deferens. 6. Triangular ligament.

practice of partly plucking away the projecting enlargement through a suprapubic wound, the operation being attended with some liability to primary and recurrent hæmorrhage. Fuller, of New York, and later Freyer, in London, found that many prostatic enlargements can be shelled out from within the prostatic sheath with only a small amount of hæmorrhage, resembling in this respect other encapsuled tumours.

The prostate gland is enclosed in a sheath of fibro-muscular tissue derived from the rectovesical segment of the pelvic fascia, in the layers of which are large veins and numerous small arteries. Through the gland runs the urethra, the wall of the canal being continuous above with the muscular and mucous coat of the bladder, and below with the walls of the membranous urethra. The substance of the gland is composed (Fig. 498) of lobules of gland

substance, each lobule being surrounded by a fibro-muscular substance which also separates the alveoli (Fig. 48, p. 130), and forms a continuous layer immediately beneath the sheath to which it is normally closely adherent. But as the prostate enlarges (and especially in the case of the softer enlargements) this fibro-muscular tissue becomes separable without great force from the sheath, and forms the capsule of the tumour as seen when shelled out. The tumour is composed of a conglomerate of enlarged lobules, each of which forms a spherical mass varying in size from a pea to a walnut.

Each little tumour is composed of a glandular tissue with an increased amount of fibro-muscular tissue around it, thus forming a fibro-adenoma (Fig. 48, p. 130, and Fig. 502, p. 1007), or the gland substance mainly disappears as the mass becomes a fibro-myoma.

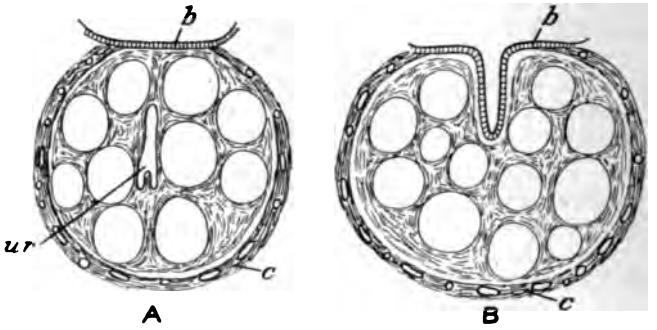


FIG. 498.—Diagram of a fibro-adenomatous enlargement of the prostate (after Fuller). A. A vertical section through the prostatic urethra. B. A vertical section where the urethra forms a groove at its junction with the trigone. *ur.* Urethra. *b.* Mucous membrane of bladder. *c.* Sheath of prostate containing large vessels, from which soft fibro-adenomatous enlargements are easily separable.

In the harder smaller enlargements the growth is diffuse, and the attachment to the prostatic sheath denser.

The tumour (Fig. 497) is prevented by the triangular ligament from enlarging in a downward direction, and owing to the greater resistance of the sheath from enlarging markedly backwards. It therefore chiefly enlarges towards the bladder, rendering that part of its sheath thinner and raising the bladder and stretching backwards the urethra. As viewed from the interior of the bladder it may first appear like a cervix uteri, with the urethral orifice nearly central. Further enlargement takes place behind the urethra, and hardly at all in front. The enlargement when in the middle line forms the so-called middle lobe (Fig. 499), which makes the axis of the urethra curve to a right angle (Fig. 497), or takes place symmetrically to either side of the middle line, forming the so-called lateral lobes, when the urethra lies in a deep groove between. Or the growth may be asymmetrical, mainly to one side, deviating the

axis of the urethra laterally. The middle lobe and lateral lobes do not appear to have any normal anatomical existence, but arise by the bulging of tumours, as in the closely analogous development of uterine fibroids.

The *cause*, as in the case of other tumours, is unknown. It is an affection of later life which does not give rise to trouble before fifty, and usually not until after sixty. It appears to slowly develop to a certain stage, and then come to a standstill, except for temporary periods of congestion. As such it may give rise to no trouble; indeed, some enlargement of the prostate may be said to be very prevalent in old age, but is not by any means universal.

The *effects* of chronic enlargement of the prostate are very serious when the outflow of urine is impeded, similar changes occurring in the bladder, ureters, and kidneys as described under *Stricture*. The prostatic urethra in all cases becomes elongated; compressed when the lateral lobes are enlarged; deflected to the right or left if only one lateral lobe is affected; or obstructed at its entrance to the bladder if the middle lobe is chiefly at fault (see Fig. 499). The bladder behind the enlargement forms a pouch in which some urine may remain after each act of micturition unexpelled, and there, mixed with pus and mucus from the walls of the inflamed bladder, undergo decomposition, owing to the action of micro-organisms, the urea being converted into ammonium carbonate, and the phosphates in consequence precipitated. A stone may be thus formed or the bladder-walls become encrusted.

FIG. 499.—Enlargement of the middle lobe of the prostate. (St. Bartholomew's Hospital Museum.)

Symptoms.—Increased frequency of micturition, especially at night; inability to propel the stream to the same distance as formerly, owing to the muscular fibres of the bladder being involved in the disease; and difficulty in commencing the act. Later, the bladder is imperfectly emptied or it becomes distended and the urine constantly dribbles away: the retained urine becomes ammoniacal and alkaline in reaction; cystitis is set up, and retention of urine may occur, or a stone form. If the condition is not relieved the ureters and pelves of the kidney become dilated and inflamed and the patient dies of exhaustion, septic absorption or uræmia.

Diagnosis.—These symptoms may depend upon causes other than enlarged prostate. It is only by a physical examination that the nature of the disease can be accurately made out. On introducing the finger into the rectum the prostate is felt enlarged. On passing a silver catheter no obstruction is met with in the urethra, *i.e.*, the

catheter passes six or seven inches without meeting with any, an then has to be well depressed before it can be made to enter th bladder. Hence, one with a longer curve than normal is required.

Treatment.—In the early stages the patient is instructed not t go longer than four hours during the day without making water an to avoid drinking much fluid late at night, also to eschew drink and medicines likely to irritate the bladder (gin, diuretics, etc. and to keep himself warmly clad.

Catheterism.—The necessity for catheterism may arise owing t the irritation and frequent micturition, the result of decompositi

Fig. 500.—Coudé (elbowed) catheter.

of the residual urine, or to acute retention from spasm followi neglect of passing water or of drinking more than usual. A larg sized soft rubber or gum-elastic coudé catheter should be passed wit all gentleness, the patient lying in bed for the purpose. A sma catheter must not be used, for there is no stricture, and the poi will only penetrate the vascular mucous membrane and cau hæmorrhage. Spasm may be overcome by a rectal suppository, l an anæsthetic, or by using a silver prostatic catheter with a lo curve. The patient should remain in bed for a day or two afte wards. If there is decomposition of residual urine, catheteris every six hours, combined or not with irrigation, is necessary, or catheter may be tied in and the bladder thus drained for a few da

Fig. 501.—Bi-coudé catheter.

until its contractile power has increased. If there is recurrence retention, or of cystitis from decomposition of the residual urine, if there is continuous dribbling away from an over-full bladde regular catheterism or "catheter life" may be started. This ma prove a success in a patient who has no occupation and is n susceptible to septic infection, or who can engage a nurse (male female) to attend to the cleaning and sterilization of his catheter But patients are apt to neglect the antiseptic directions given the to prevent hæmorrhage and cystitis; nor can regular asepti catheterism be carried out by a working man.

Palliative measures.—Suprapubic drainage through a cannula an perineal drainage (Harrison's operation) are open to numerou objections previously mentioned. They are inconsistent with activ life, the suprapubic more than the perineal, and may be reserve

for the later stages of a case, when the patient is perforce under nursing care.

Cauterisation of the prostate.—Bottini's operation. The prostate has been punctured through the rectum or through the urethra. These procedures are open to the danger of septic inflammation and sloughing, involve an operation in the dark, and may produce little or no benefit.

Castration, orchectomy, or division of the vas deferens, vasectomy.—This treatment was introduced in order to cause the prostate enlarged by *new growth* in an *old* patient to undergo the atrophy which the *normal* prostate does when *young* animals and boys are castrated. But there is no necessary analogy. In some cases of soft and vascular enlargement of the lateral lobes temporary good has ensued, the patients being able to dispense with catheterism, but the improvement has in many cases only lasted a few months. For the harder fibrous masses and formation of a middle lobe no good follows. Moreover, some patients are disturbed mentally, owing to the loss of sexual power; others have rapidly aged or become demented from this loss, it has been conjectured, of the stimulating influence of testicular secretion (Brown-Séquard's spermin). Stones have been overlooked and the effects of an ill-drained bladder have spread to the kidneys. Whichever operation is done it should be bilateral. *Castration* is the more effectual, though the severer, procedure. *Orchectomy* is most easily performed through a short incision through the posterior raphé of the scrotum, through which each testicle can be drawn out and the cord securely ligatured. *Vasectomy* is done by exposing the vas deferens over the pubic spine outside the external ring, and cutting out an inch or more of the vas. This treatment is already obsolescent.

Suprapubic prostatectomy is now regarded as by far the best treatment. Fuller of New York, and subsequently Freyer in London, have shown with what great success it may be done on old patients. It is especially suited for large soft growths with a large bladder, and now that its safety is proved should be advised before septic cystitis and pyelitis have set in. The pelvis being raised, the prostate is exposed by suprapubic cystotomy (see p. 998). Pouches and sacculi are sought for and cleared of stone and débris. Then with the finger-nail or blunt-pointed scissors, the mucous membrane covering the prostate is cut through above and behind the ending of the urethra, the finger inserted, and the tumour gradually separated and shelled out from its sheath, aided by the surgeon or his assistant's gloved finger in the rectum pushing up the prostate. The tumour having thus been loosened from its attachments, the urethra, where it runs in a groove between the lateral lobes, is raised with the bladder, and where it perforates the upper part of the tumour is torn from its junction with the bladder mucous membrane above and from its continuation with

as described, and the urethra cut by a median incision, not torn. But a bougie may be passed once or twice after healing to make certain. Spencer has repeatedly performed this operation.

Tubercle of the prostate and vesicula seminalis, though occasionally primary in the prostate, is more often secondary to tubercle of the epididymis. It may also occur in the course of general tuberculosis. The tubercle occurs as caseous nodules, which may often be felt on palpation through the rectum. Later the nodules break down into abscesses which leave sinuses riddling the organ, and the tubercle spreads to the bladder, ureters, and kidneys, and to the epididymes if not primarily affected. The

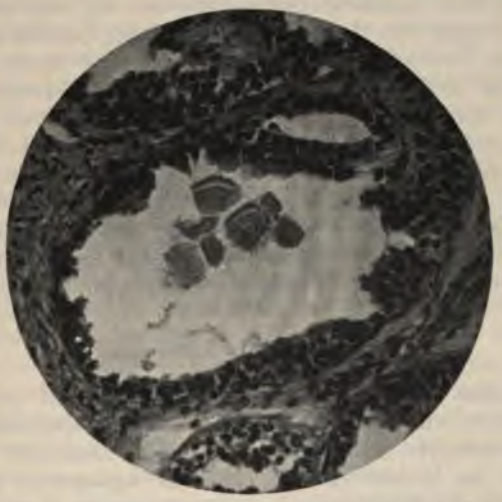


Fig. 502.—Prostatic calculi. Photograph of a section through a fibro-adenomatous prostate; dilated alveolus contains small concentric masses of inspissated mucus, in which lime salts are being deposited to form calculi.

disease is attended by pain, hæmorrhage, irritation of the bladder and pus in the urine; but its diagnosis will depend on the presence of tubercle in other parts; on the detection of nodules in the prostate on palpation by the rectum, and of the tubercle bacillus in the urine. The caseous material may be removed through the semilunar incision in the perineum described above and the cavity filled with gauze.

Malignant disease.—Carcinoma in the old, and sarcoma in the young, may occur in the prostate, but both are rare. Pain, increased frequency in micturition, with passage of blood, often pure, at the end of the act; the presence in the urine of shreds of the growth; the detection in the rectum of a swelling of the prostate of unequal consistency and of rapid growth; enlargement

the membranous urethra below. The tumour is now loose in a pocket under the bladder mucosa, from which it is withdrawn with the finger, aided by lithotomy forceps. The hæmorrhage is not great, because the sheath is not widely torn. The operation thus differs from McGill's, which consists in plucking off with forceps the projecting portions of the tumour, including the bladder mucous membrane and the prostatic sheath stretched over the tumour. In this procedure the large veins and numerous arteries which run in the sheath are injured, and there is much more primary hæmorrhage and a danger of its recurrence, whilst a portion of the tumour is left behind torn across and oozing freely. After pressure with a hot sponge the bladder may be closed, the superficial wound filled with gauze, and a catheter tied in the urethra. Suprapubic drainage may be kept up for a few days. After this the patient begins to pass water and regains full power over his bladder.

Perineal prostatectomy.—This is an operation suitable for the smaller, harder prostates, composed mainly of fibrous tissue closely adherent to the sheath and when the bladder is small, much hypertrophied and contracted, and the prostate bulges, especially downwards; it also affords better drainage. The patient is placed in the lithotomy position, with a pillow under the sacrum. A semilunar incision is made across the central point of the perineum, the two horns ending on either side of the anus, the incision deepened at the sides, the transverse perineal and bulbar arteries being clamped as divided and later tied, and the anus and rectum gently pushed backwards. The bulb and membranous urethra, the prostate, and behind this the prostatic pouch, will now be exposed. The membranous urethra is next opened by an exactly median incision back to the prostate. A rectal speculum is passed into the bladder, with the slit downwards, and through the slit the prostate is divided with a cautery knife in a backward direction as far as the pouch, or if suitable the enlargement may be shelled out from within the sheath or partly cut away with scissors. Meanwhile the prostate may be drawn down by a volsella, or by inserting a rubber bag into the bladder, inflating it, and drawing on the stem. The bladder is next explored for stone, all bleeding except oozing stopped by ligatures, which can readily be done, as the parts are completely in view. A rubber tube is then inserted and packed round with gauze. After twenty-four hours the oozing has stopped, and the tube being removed, the urethra falls naturally together, and the patient in a day or two will begin to pass water through the penis, and in a week or two there will be no further leakage from the perineum. For the skin wound also falls naturally together when the legs are brought down, as can be seen by turning the patient on his side, and healing follows by second intention, leaving a short ridge across the centre of the perineum. There is no tendency to contraction, when the neck of the bladder is guarded by the speculum

track established by drawing a drainage tube through, the track being afterwards lined with epidermis either by raising and drawing through it the urethral groove, or by inserting a strip of epidermis having its surface turned inwards so as to line the track.

Simple or non-gonorrhœal urethritis is a mucopurulent inflammation which may be set up by injury, catheterism, the insertion of a foreign body, the impaction of a stone, or, in a milder form, by gout, alcoholism, and the contact with leucorrhœal and menstrual discharges; or it may follow upon an acute specific fever such as typhoid or mumps when complicated by testicular inflammation, or it may be caused by the bursting of an abscess. But it must be remembered gonorrhœa, besides being slight at the onset, may remain latent for years, and yet be lighted up again by one of the above causes without any fresh exposure to gonorrhœal infection. The finding of gonococci is proof of gonorrhœal infection, but the converse does not hold, for gonococci are often not found in old-standing infections. Urethritis produced by injury or catheterism is due to infection by pyogenic organisms, and as a consequence of septic catheterism cystitis and nephritis may follow. The treatment is similar to that for gonorrhœal urethritis.

Gonorrhœal urethritis.—For a general description of gonorrhœal infection and of the gonococcus, see p. 68 and Figs. 17 and 18.

Symptoms.—In the *first stage*, usually lasting from a few days to a week, there is some itching about the external meatus followed by a yellowish-white discharge. In the *second or acute stage*, there is great pain on urination, a thick yellowish-green discharge, redness and swelling about the lips of the meatus, and often fever and constitutional disturbance. In the *third or chronic stage*, which, when prolonged, is known as *gleet*, the discharge becomes thin and watery, and there is no longer pain on urination.

The *treatment* varies according to the stage of the disease. Generally it may be said that at the onset a smart purge should be given and the bowels subsequently kept slightly relaxed by saline aperients; whilst, throughout its course, stimulants of all kinds must be withheld, demulcent drinks freely taken to dilute the urine, the parts kept scrupulously clean, the testicles supported in a suspensory bandage, and active exercise and exposure to cold and wet avoided. Attempts should be made to confine the inflammation to the anterior part of the urethra by getting the patient to pass water, and thus irrigate his urethra before any local application is made. In the *first stage* the so-called abortive treatment is often successful. It consists in injecting solutions having antigonococcal and astringent actions. A 4 per cent. solution of cocain and eucain, not exceeding $\frac{1}{2}$ grain of the former, is first injected, and this is followed after a few minutes by nitrate of silver (1 per cent.) or mercury perchloride (1 in 1,000), or protargol (1 to 2 per cent.), or mercurol ($\frac{1}{2}$ to 2 per cent.). An inflating urethroscope may

be inserted and the solution applied on a swab, or a long nozzle of a syringe is inserted and the injection made drop by drop as the nozzle is withdrawn. To undergo the above treatment the patient should remain in bed under full medical control; otherwise it is better to select a milder measure. This consists for the first stage of the insertion of a bougie of iodoform, oil of eucalyptus and of theobroma, into the urethra after the patient has passed water, and allowing it to dissolve there. This can be frequently repeated. In anterior urethritis care should be taken not to contaminate the posterior urethra. Copaiba, cubebs, or sandal-wood oil may be given internally. In the second stage a soothing plan of treatment is to be recommended by aperients and such medicines as hyocyamus and bicarbonate of potash, or salicylate of soda or salol if there are any rheumatic symptoms, or urotropin if cystitis threatens, with non-irritating drinks, and sitting in a hot bath. In the third stage, astringent injections, especially chloride, or sulphate or sulphocarbolate of zinc (gr. i. ad ℥j.) and nitrate of silver (gr. ¼ increased to gr. iij. ad ℥j.) combined with the internal use of copaiba (♏ x. to xx.), cubebs (gr. x. to xxx.), or sandal oil (♏ x.), in the form of capsules or cachets, are indicated. This stage is often very difficult to cure, and where one remedy or injection fails, another must be tried. The passage of a full-sized bougie is at times of much service. Spring bougies coated with antiseptic and astringent ointments have been highly recommended. In very obstinate cases the urethra should be examined by the urethroscope, and with its aid local applications of nitrate of silver made to any congested, ulcerated, or granular surface that may be discovered. When the inflammation has extended beyond the triangular ligament (*posterior gonorrhœa*) mild antiseptic irrigations, permanganate of potash (1 in 600), or boric acid, are the most suitable.

The cure of gonorrhœal urethritis is a matter of time, varying greatly with the individual. Two years of absolute abstention from coitus, starting from the disappearance of all symptoms, may be given as a rough average. Patients are often said to be cured after a course of treatment when there is no discharge, no sticking of the meatus in the morning, no débris in the urine, no gonococci; but such a statement is doubtful in the extreme. What often happens is that the patient marries and frequent coitus sets up a slight relapse, which may be unnoticed by the patient, but the wife begins to suffer, after or apart from pregnancy, from one of the many pelvic complications of gonorrhœa, slight or severe, which beset women, the result being partial or complete sterility or some definite lesion.

Complications of gonorrhœa.—Complications of some kind frequently occur during an acute attack of gonorrhœa. They may be conveniently classified according as they depend upon:—
A. *The local inflammation of the urethra*—1, balanitis; 2, chordee,

3, phimosis; 4, paraphimosis; 5, lacunar and perineal abscess, liable to be followed by penile or perineal fistulæ; 6, retention of urine; 7, hæmorrhage; 8, warts; 9, stricture; 10, induration of the penis (rare). B. *The extension of the inflammation along the genito-urinary mucous membrane* — 1, prostatitis; 2, cystitis; 3, inflammation of Cowper's glands; 4, vesiculitis; 5, epididymitis; 6, pyelitis and nephritis (very rare); and in the female: 7, metritis; 8, salpingitis; 9, pelvic peritonitis and cellulitis. C. *The extension of the inflammation to the lymphatics of the urethra*— 1, lymphangitis; 2, bubo, and 3, blood-poisoning. D. *The local inoculation of distant mucous membranes with the discharge* — 1, gonorrhœal conjunctivitis; 2, nasal catarrh; and 3, catarrhal inflammation of the rectum. E. *The absorption by the blood-vessels of the septic products*—1, gonorrhœal arthritis (the so-called gonorrhœal rheumatism); 2, gonorrhœal sclerotitis; and 3, septicæmia and pyæmia with gonorrhœal endocarditis. Of these complications, some are rare, whilst others, as balanitis, chordee, phimosis, paraphimosis, epididymitis, bubo, retention, and stricture are common in the male and pelvic inflammation in the female. Most of these complications are described under Diseases of the Various Organs in other parts of the book. Here a short account of the following only will be given.

Balanitis, or inflammation of the glans penis, often occurs in gonorrhœa. The glans is red and swollen, of a bright red colour, and often excoriated. Cleanliness, astringent lotions, and rest are all that is necessary.

Chordee, or painful erection of the penis, is very common in gonorrhœa. The erected penis is curved downward or to one side owing to the inflammatory products in the corpus spongiosum, or in the corpus cavernosum, preventing the penis from becoming equally distended. It occurs chiefly when the patient is warm in bed, and greatly disturbs his rest. The *treatment* consists in the administration of a purge and such sedatives as potassium bromide or of morphine and opium in the form of a suppository, Dover's powder, the local application of cold, or sitting in a hot bath before going to bed.

Inflammation of Cowper's glands sometimes occurs, and then usually late in the second stage of gonorrhœa. It may be known by the formation of a painful swelling on one or both sides of the middle line of the perineum. The swelling, at first hard, subsequently becomes soft and fluctuating as pus forms. It may be distinguished from ordinary perineal abscess by not being in the middle line of the perineum. *Treatment.*—Warmth to the perineum, and, when suppuration has occurred, a free incision.

Lymphangitis and bubo.—The inflamed lymphatic vessels appear as red streaks running along the dorsum of the penis to the inguinal glands, the penis itself, especially the glans, being

swollen, turgid, and dusky red in colour. It may terminate in suppuration of the inguinal glands, or even in blood-poisoning. In the ordinary *gonorrhœal bubo*, inflamed lymphatics are not as a rule visible on the penis, and the inflammation which may occur both in and around the glands generally terminates without suppuration.

Treatment.—Rest, and attention to the bowels, is all that is usually required. If, however, suppuration threatens, a free incision must be made and hot boric acid fomentations applied. To open a bubo it has been customary to make a vertical incision by puncturing and cutting out as soon as pus has formed. A much better method is to operate as soon as the red œdematous skin shows that suppuration is likely to occur. The patient is laid on his back, nitrous oxide gas given, the bubo incised parallel to Poupart's ligament, the softened gland scooped out, the cavity wiped with an antiseptic and filled with a gauze strip. A little of this is pulled out each day, and soon the cavity is lined with granulation, and the skin falls together and unites by second intention. Thus a sinus is avoided and there results a linear scar hidden in the skin fold of the groin. A sinus follows when the bubo is allowed to remain unopened till it bursts, or is aspirated or punctured later. It may be treated first of all by wiping it out with pure carbolic acid. This failing, the sinus must be laid open, scraped freely and stuffed with gauze.

Chronically inflamed, indurated indolent glands should be treated by rest in bed, combined with pressure by a pad of wool and spica bandage. A partly indurated, partly suppurating mass of glands is treated on the above lines—by scraping, rest and pressure. In neglected cases and old-standing sinuses, it may be necessary to excise the whole packet of glands, but healing is prolonged and there may be set up chronic lymphatic obstruction. Exceptionally a bubo is followed by phagedenic ulceration, which rapidly eats into the epigastric or even the iliacal or femoral vessels, and sets up fatal hæmorrhage. It requires energetic treatment. See *Phagedenic Ulcer*, p. 34.

Stricture of the Urethra.

True, or organic stricture of the urethra is a cicatricial narrowing of the canal at one or more spots, due to disease, injury, or congenital defect. A temporary narrowing of the urethra may also occur from spasm of the muscular tissue surrounding it, or from congestion of its lining membrane, conditions to which the terms *spasmodic* and *congestive* stricture are sometimes applied. Such, however, seldom or never occur without the co-existence of organic stricture. Obstruction of the urethra by a calculus, an enlarged prostate, or by pressure from without, as from an

abscess or fractured pelvic bone, should not be spoken of as stricture.

Cause and formation of stricture.—A stricture is generally the result of chronic inflammation, such as a neglected gonorrhœa or gleet, or more rarely, a simple urethritis in a gouty subject. In such cases the mucous and sub-mucous tissues become infiltrated with inflammatory products, which are ultimately organised into fibrous tissue; and this again slowly contracts, narrowing the canal. More rarely a stricture may be caused by the contraction of a cicatrix following laceration or rupture of the urethra, produced by injury inflicted either from within, by the careless passage of instruments or the use of too strong injections, or from without, by kicks, falls, etc., on the perineum. Occasionally it may be due to the contraction of the cicatrix following a urethral chancre. In some instances no cause can be ascribed. A few cases are congenital.

Fig. 503.—The effects of obstruction to the outflow of urine from the bladder on the urinary apparatus.

Varieties. — Organic strictures have been divided (1) according to their cause, into *idiopathic* and *traumatic;* (2) according to their anatomical appearances, into *linear, annular, irregular* or *tortuous, bridle* or *pack-thread,* and *tunnelled,* terms which sufficiently explain themselves; (3) according to whether an instrument can or cannot be passed, into *permeable* and *impermeable;* (4) according to their behaviour, into *simple, sensitive,* or *irritable,* and *resilient, contractile* or *recurring;* and (5) according to their structure, into *fibrous, elastic,* and *cartilaginous.*

Situation.—Stricture may occur in any part of the urethra save the prostatic. It is most common in the bulbous part of the spongy portion. Otis and others, however, maintain that it is most often found in the anterior part of the urethra, and that what have been considered deep strictures are only spasmodic conditions consequent upon the reflex irritation of the true stricture in front. In the penile portion of the urethra, strictures are usually multiple; in the membranous portion they are always traumatic.

Results.—When a stricture, or indeed any mechanical obstruction

to the free flow of urine from the bladder, such as a long prepuce, an enlarged prostate, a narrow meatus, etc., has existed some time, serious structural changes (Fig. 503) occur in the urinary apparatus on the proximal side of the lesion, *i.e.*, in 1, the urethra behind the stricture; 2, the bladder; 3, the ureters; and 4, the kidneys. Thus:—

1. The *urethra* behind the stricture becomes dilated, and ulceration may occur, leading to perforation, urinary abscess and perineal fistula; or rupture may take place suddenly during straining, and be followed by extravasation of urine.

2. The *bladder*, in consequence of its efforts to expel the urine, becomes thickened from hypertrophy of its muscular coat. The mucous membrane may become inflamed and thickened; or owing to the pressure of the urine may be protruded between the muscular fasciculi, forming sacculi, in which stale urine may collect or a calculus form or lodge.

3. The *ureters* become dilated, their muscular coats hypertrophied, and their lining membrane sometimes inflamed.

4. The *kidneys* become disorganised, in part from the backward pressure of the retained urine and in part from the spread of inflammation from the bladder up the ureter to the pelvis. See *Diseases of Kidneys*, p. 955.

Symptoms.—A gleety discharge, increased frequency of micturition, and perhaps, some pain in the act, twisting or forking of the stream, or the escape of a few drops of urine after the stream has ceased, are early signs of stricture. Then the stream gets gradually smaller, and is passed with increasing difficulty and straining, till finally the urine may be voided only drop by drop, or complete retention may set in. In some instances an attack of retention is the first sign of the disease. In neglected cases the straining may produce piles or prolapse of the rectum; or cystitis may be set up and the urine become ammoniacal and turbid from the presence of mucus and pus; or the bladder may become over-distended, and the urine dribble involuntarily away. This condition of overflow should be carefully distinguished from incontinence (see p. 984). At first there are usually no constitutional symptoms; but as the obstruction begins to tell on the bladder and kidneys, dyspeptic troubles are developed; the patient loses weight, his countenance becomes anxious, he suffers from chilliness and occasional rigors, from pain in the loins, and later, from feverish attacks and unmistakable signs of kidney disease. Thus a stricture which in itself, if kept properly dilated, is not a serious disease, becomes so when neglected and chronic bladder and kidney trouble are allowed to be set up. It may then end fatally from an intercurrent attack of acute cystitis or nephritis, or from extravasation of urine and its consequences occurring during an attack of retention.

A *diagnosis* can be made with certainty only by examining the urethra with instruments. First take a No. 8 or 9 black bougie or catheter, and if this passes easily try successively larger sizes till the obstruction is met with. If, on the other hand, it will not pass, try a smaller bougie till one is found that will go into the bladder. If the obstruction to the passage of the bougie is met with within six inches of the meatus, a stricture exists: but if it is further than this the case is probably one of enlarged prostate. Do not mistake the catching of the end of the bougie in a lacuna or at the triangular ligament, or the spasm that may be present on the first trial, for a stricture. Having discovered the stricture,

FIG. 504.—Bulbous stem.

measure the distance from the meatus on the catheter or bougie. Next pass a bulbous stem (Fig. 504) through the stricture, and then withdraw it, noting on the stem where the bulb is caught in the act of withdrawal. This, when compared with the distance noted on the catheter, will indicate the length of the stricture. In the same way the existence of other strictures can be discovered. The calibre of the stricture may be measured by Otis' urethrometer (Fig. 505).

The method of passing a bougie or catheter can be much better learnt by five minutes' practice than by any written instructions. Here only the general rules for passing such will be given.

FIG. 505.—Otis' urethrometer.

1. Carefully examine the instrument to see that it is quite clean (see p. 180), aseptic, perfectly smooth, not defective in any part, and, in the case of a catheter, that it is pervious, in order to avoid respectively the dangers of septic infection, laceration of the urethral mucous membrane, the breaking off of the end of the catheter in the stricture, and the annoyance of finding that when the catheter has been passed it is choked and urine will not flow through it. 2. Warm and lubricate the instrument with glycerine; a cold catheter is unpleasant to the patient, and tends to produce spasm; a dry catheter does not glide easily along the urethra. 3. Place the patient in the recumbent position if instrumentation is to be practised for the first time, lest faintness be produced. In old-standing cases, where the urethra is callous, the patient may

stand with his back against a wall. 4. Pass the instrument with the greatest gentleness—use no force, and keep the beak, except for the first inch or so, along the roof of the urethra.

The difficulties that may be met with in passing an instrument are: 1. The point may catch in a lacuna or fold of mucous membrane. This is best avoided by keeping the point at first on the floor of the urethra. 2. It may hitch where the urethra passes through the triangular ligament. Should it do so, withdraw it a little, and direct the point against the roof of the urethra. 3. It may enter a false passage. This may be known to have occurred (*a*) by the handle being deflected from the middle line, (*b*) by the catheter being felt to be out of the right passage by the finger in the rectum, (*c*) by free bleeding if the false passage is recent, (*d*) by no urine escaping, (*e*) by the point not moving freely as it does when in the bladder. The formation of a false passage may be prevented by using no force; and entering an old one may be avoided by using a silver catheter and directing its point along the wall of the urethra opposite to that in which the opening into the false passage is situated.

The local and constitutional effects that occasionally follow the introduction of instruments.—Among the *local effects* may be mentioned—1, hæmorrhage; 2, false passage; 3, abscess; 4, extravasation of urine, and 5, inflammation of the prostate, epididymis, or bladder. Among the *constitutional effects*—1, syncope; 2, rigors; 3, urethral fever; 4, suppression of urine; and 5, pyæmia. *Local effects.*—1. Hæmorrhage may be due to laceration of the mucous membrane of the urethra by the careless passage of the instrument, or to congestion of the urethra in the neighbourhood of the stricture; in either of these cases the blood may flow on the removal of the catheter, the point of which, moreover, will be blood-stained. Hæmorrhage, however, may come from the kidney, consequent upon reflex congestion due to the irritation of the neck of the bladder by the catheter. The blood will then only appear in the urine after some time has elapsed (see *Hæmaturia*, p. 985). 2. A false passage may be produced by using too much force, or by applying force in the wrong direction. It is known to have been made, by the catheter being felt to slip suddenly onwards, by the handle deviating from the middle line, by the point being felt out of the urethra by the finger in the rectum, and by the patient complaining of severe pain. The catheter should be at once withdrawn and not passed again for a week or longer, to allow the wound to heal. 3. Abscess; 4, extravasation of urine; and 5, inflammation of the prostate, epididymis, and bladder require no comment here. *General effects.*—1. Syncope occasionally occurs on the first passage of a catheter. It is best avoided by passing the instrument with the patient lying down. 2. The rigors which sometimes follow the first introduction of an instrument appear to

depend upon some nervous shock, and may occur where all gentleness has been employed and no local injury whatever has been inflicted. 3. Urethral fever is most frequent in old people, and may supervene within a day or two of the first catheterisation. It begins with rigors followed by high fever, and usually terminates in a few days with profuse sweating. Occasionally, however, it may end fatally, in which case there is nearly always some chronic kidney disease discovered at the autopsy. Sir Andrew Clark has called attention to the possible occurrence of death after the passage of an instrument in old men without any kidney or bladder trouble to account for it. 4. Where suppression of urine has been observed there has always been some pre-existing kidney disease. 5. Pyæmia is rare, but has occasionally been noted.

The *treatment* of organic stricture resolves itself into restoring the patency of the urethra by causing the absorption and destruction of the inflammatory or cicatricial material producing the obstruction, and subsequently preventing re-contraction. The

FIG. 506.—Metal bougie (Lister's). It is highly polished and without chinks which collect septic material, has an olive head to avoid perforating the urethra, a stem gradually increasing through three sizes, and shaped to correspond with the curve of the urethra as shown in frozen sections.

methods employed for restoring the patency of the urethra are: 1. *Slow dilatation.* 2. *Rapid dilatation.* 3. *Forcible dilatation or splitting.* 4. *Division of the stricture from within* (internal urethrotomy). 5. *Division of the stricture from without* (external urethrotomy). 6. *Destruction of the stricture by caustics.* 7. *Electrolysis.* Treatment by caustics and electrolysis may be said to have now become obsolete, and will not be further described. Of the other methods slow dilatation is no doubt the simplest and safest, and is the one that in the large majority of cases should be used. Where, however, time is an object, or the stricture cannot be dilated by the slow method beyond the size of a No. 4 or 5 catheter, or severe constitutional or local symptoms are set up on each occasion that a catheter is passed, rapid dilatation may be tried by the metal bougie (Fig. 506). Where again the continual presence of a catheter in the urethra cannot be borne on account of the local irritation which it causes, or the stricture is resilient and rapidly re-contracts after it has been fully dilated, internal urethrotomy may be practised, especially if the stricture is in the penile portion of the urethra. Further, when the stricture is of cartilaginous

consistency, and will not yield to dilatation, or the perineum, in addition, is riddled with sinuses, external urethrotomy by Syme's or Wheelhouse's method may be performed. Lastly, when, after persistent attempts, it is found that an instrument cannot be passed through the stricture, external urethrotomy by Wheelhouse's method may be undertaken. When the symptoms are urgent, as from retention or extravasation of urine, other measures may be required. (See *Retention and Extravasation of Urine*, pp. 1026 and 1028). Forcible dilatation or splitting do not commend themselves to our judgment, and should not, in our opinion, be employed.

If a bougie or catheter will not pass on the first attempt it must not at once be assumed that the stricture is impervious, as it may yield on a future occasion; but gentle and persevering attempts with fine catgut, filiform, silk, or whalebone bougies, should be made. The patient, presupposing there is no retention, may be asked to pass water, and whilst the urine is flowing, and the stricture is in consequence dilated by the stream, a bougie one or two sizes smaller than the stream may sometimes be slipped in. If the point of a bougie or catheter is firmly grasped, indicating that it is in the mouth of the stricture, gentle pressure may then be used to push it onwards. If in any of these ways a fine bougie can be got in, it should not be removed till the patient is compelled to pass water, when a small catheter may be subsequently substituted for it, or a railway catheter slid over the bougie before the latter is removed. If after persevering attempts, even with the patient under the influence of an anæsthetic, success is not attained the patient should be prepared for a further trial by rest in bed for a week or so, daily hot baths, purgatives, and the administration of opium. These means having failed, a cutting operation, of which Wheelhouse's is, in our opinion, the best, must be performed.

Slow or intermittent dilatation is the simplest and safest method of treatment, and does not usually necessitate the patient leaving his ordinary employment. The various catheters and bougies employed hardly require description here. All that need be said is that the soft, flexible, black bougie, with a bulbous end is now as a rule generally preferred, or the metal bougie (Fig. 506) may be used. A bougie should be passed once or twice a week beginning with the largest instrument that can be introduced without using force. On the next occasion the same instrument should be again passed and at once withdrawn, and the next size substituted for it, and allowed to remain for a few minutes. In this way the urethra is gradually dilated to its full size. Formerly it was not thought necessary to pass a larger instrument than No. 12, English scale; now, however, few surgeons are satisfied till the dilatation has been carried to the size of No. 14. To prevent re-contraction the patient should be taught to pass a bougie

for himself, and instructed to do so at first once a week, then every month or six weeks, and subsequently two or three times a year, according to the tendency the stricture may show to re-contract.

Continuous or rapid dilatation is very useful: 1, when time is an object; 2, when much difficulty has attended the introduction of an instrument owing to the tightness of the stricture or presence of a false passage; 3, when the passage of an instrument causes great pain, irritation, hæmaturia, or rigors; 4, when gradual dilatation has failed. Continuous dilatation consists in tying in a silver catheter for twenty to forty-eight hours, and, on removing it, tying in a size or two larger, and so on till the urethra is fully dilated. The instrument should not fit the stricture too tightly, and its end should not project far into the bladder. It is better, as soon as the stricture begins to yield, to substitute a gum-elastic for a metal instrument. This method necessitates confinement to the couch or bed for ten days or a fortnight, and is not unattended with risk. It frequently causes great pain; and rigors, fever, urethritis, cystitis, epididymitis, and ulceration of the bladder from the irritation of the point of the catheter, may be induced by it. If the catheter merely causes pain, opium may be given, or the urethra be injected with a solution of cocain; whilst if it produces rigors, fever, cystitis, etc., it must be removed. It is generally believed that the mere presence of a catheter in the stricture causes the absorption of the inflammatory material in the submucous tissue, and that this result is not affected by mechanical stretching, since a catheter that does not fit the stricture tightly answers better than one that does, and causes less irritation. The method of tying in a catheter will be learnt by every student whilst dressing. In place of tying in a catheter rapid dilatation may be accomplished by Lister's graduated sounds, several of larger and larger size being passed at each sitting.

Forcible dilatation, splitting or rupture (*Holt's operation*) is done by passing through the stricture an instrument consisting of two parallel blades with a central stem fixed between them, and then over this stem forcing a tube the size of the urethra, thus separating the blades and splitting or rupturing the stricture. The operation is not unattended with danger, and is more liable to be followed by an early relapse than either rapid dilatation or internal urethrotomy. Indeed, internal urethrotomy has now to a great extent taken its place in the treatment of linear, contractile, and penile strictures (the strictures to which splitting was said to be especially adapted), since the cicatrix following laceration of the tissues is much more prone to contract than that following a clean cut. Holt's instrument is still employed by some surgeons, but is then used in a more gentle fashion, so as to stretch the stricture like the finger does a glove.

Internal urethrotomy, or division of the stricture from within the urethra, should be undertaken only when the simpler and safer method of treatment by dilatation has failed. It consists in making a clean longitudinal cut, with a guarded knife, completely through the stricture, and subsequently in keeping the edges of the wound apart by the passage of a full-sized bougie till the ovoid gap thus left has been filled with new tissue—*the cicatricial splice* of the American surgeons. The cicatrix following a clean cut shows much less tendency to contract than a cicatrix following a laceration or rupture; hence the superiority of internal urethrotomy over the method of *splitting or rupture.* The cases in which it is advocated are: 1. Intractable strictures that cannot be dilated beyond the size of a No. 5 or 6 catheter. 2. Strictures which rapidly re-contract after dilating instruments are discontinued. 3. Cases in which the passage of instruments is constantly followed by retention of urine, hæmaturia, rigors, urethral fever, or other constitutional symptoms. But it is very questionable if external urethrotomy

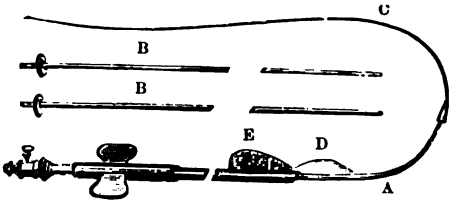


Fig. 507.—Teevan's urethrotome. A, staff; B, B, stylets; C, olivary bougie; D, knife; E, knife-sheath.

is not the better operation for these last conditions. Internal urethrotomy is especially applicable to strictures within three or four inches of the meatus. Anæsthesia of the urethra should be induced by injection with a 20 per cent. solution of cocain. The operation may be done by cutting—1. From before backwards; and 2. From behind forwards. The latter method requires that the stricture should be dilated up to the size of a No. 4 or 5 catheter, to enable the sheathed blade of the instrument to be passed through it; the former can be done if the stricture will admit a No. 2 catheter. There are many ways of performing both methods. The following appear to be the best:—

1. *Internal division of the stricture from before backwards.*—If the stricture is sufficiently near the meatus it may be simply divided by a straight blunt-pointed bistoury; otherwise Teevan's urethrotome (Fig. 507), which is a modification of Maisonneuve's, and Berkeley Hill's instrument should be used. Teevan's consists of a slender staff A with an open slot running along it to within two inches of its end. Within this staff is fitted a stylet B. The slender olivary bougie C is first wriggled through the stricture

into the bladder; the staff A is then screwed on to the bougie and made to follow it, the bougie coiling up in the bladder. When the stylet is withdrawn the urine will escape if the instrument has passed into the bladder and not into a false passage. The knife D, covered by the sheath E, is then placed inside the slot, and the stem of the sheathed knife is pushed down to the stricture. The knife is next protruded to half an inch, and then withdrawn in its sheath, which is pushed forward to see if the stricture is completely divided. If it be not, the process is repeated. Teevan divided the roof of the urethra to avoid the bulb, and the consequent danger of hæmorrhage from that structure. As soon as

FIG. 508.—Thompson's modification of Civiale's urethrotome.

the canal was free from one end to the other he passed a full-sized silver catheter to prove that the calibre of the urethra had been restored, and completely emptied the bladder. He advised that a catheter should not be left in, and no instrument passed for four days.

2. *Internal division of the stricture from behind forwards.*—(*a*) Sir Henry Thompson uses a modification of Civiale's urethrotome (Fig. 508). He first dilates the stricture to the size of a No. 4 or 5 bougie; then passes the bulb of the urethrotome, which contains the guarded knife, about a third of an inch beyond the stricture; protrudes the knife by a suitable arrangement in the handle, and

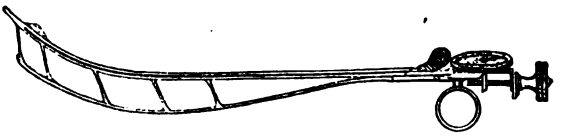


FIG. 509.—Otis' urethrotome.

draws it firmly towards the meatus for about an inch and a half, dividing the stricture along the floor of the urethra, and a little of the healthy mucous membrane at each end of it. He then passes a No. 14 or 16 bougie, and if this is felt to be held at any point, re-introduces the urethrotome, and divides what remains of the stricture. A No. 12 gum-elastic catheter is then tied in for twenty-four to forty-eight hours. (*b*) Dr. Otis uses what he calls a dilating urethrotome (Fig. 509). It is introduced beyond the stricture, the screw at the handle is turned, dilating the instrument up to a millimetre or two beyond the normal calibre of the stricture in order to make the latter completely salient. Then the blade is drawn through the stricture, dividing it from behind forwards.

Otis claims that when the stricture has been completely divided, re-contraction does not occur. This, however, is contrary to the experience of surgeons generally, the stricture returning (though less rapidly), as it does after all methods of treatment, if a bougie is not occasionally passed.

For strictures in front of the scrotum, internal urethrotomy is a very successful operation; but in deeper situations it has been followed by abscess, severe hæmorrhage, extravasation of urine, cystitis, nephritis, pyæmia, shock, also sudden death from heart failure. It would appear to be attended with a mortality ranging from 1 to 3 per cent. It does not dispense with instrumentation afterwards.

External urethrotomy, or opening the urethra from the perineum, may be required for two distinct conditions. 1. For certain strictures which, though pervious to instruments, are of an intractable nature. Here the operation known as Syme's should be done. 2. For strictures through which, even after the utmost perseverance, an instrument cannot be passed. In these cases the stricture may be divided by Wheelhouse's modification of the old

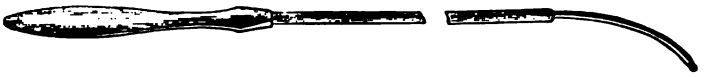


Fig. 510.—Syme's staff.

method of perineal section; or the urethra may be opened in cases of retention by Cock's method, *i.e.*, behind the stricture at the apex of the prostate, and the stricture left undivided in the hope that, relieved from the pressure and irritation of the urine, it may become pervious to instruments.

Syme's method of external urethrotomy or perineal section.—Syme advises this operation for—1, irritable, and 2, contractile strictures "that are indomitable by the ordinary means of treatment." For such, however, internal urethrotomy is now generally preferred, and Syme's operation reserved for—3, indurated and cartilaginous strictures, complicated by intractable perineal fistulæ where dilatation has failed. Introduce Syme's shouldered staff (Fig. 510) so that the slender part passes through the stricture into the bladder, and the shoulder of the thicker part rests against the face of the stricture. Place the patient in the lithotomy position, and make an incision one inch and a quarter long, through the middle line of the perineum, over the stricture. Having felt the staff distinctly in the wound, take it in the left hand, "and guarding the knife with the right forefinger, insert its point into the groove on the bladder side of the stricture, and divide the stricture from behind forward. When completely divided, the thicker part of the staff can be pushed on into the bladder." A full-sized catheter should

be tied in for twenty-four hours. The difficulties attending Syme's operation are—1, to be sure that the staff is in the bladder, and not in a false passage; and 2, to pass a catheter afterwards. These are obviated by the modification suggested by Teevan. He advises a catheter-staff with a groove on its convexity, along which the knife can be run to divide the stricture. When introduced, it is known to be in the bladder by the escape of urine on removing the

FIG. 511.—Wheelhouse's staff.

stylet. A bougie is then screwed on to its end, and a gum-elastic railway catheter is passed over the bougie and staff till arrested by the stricture, and is there fixed by a screw. When the stricture is thought to be divided, the catheter is advanced over the staff; and if all is divided, will pass on into the bladder. The catheter-staff can now be withdrawn, and the catheter, if desired, left in the bladder. Syme's operation is very useful, but like other methods, is liable to be followed by re-contraction if a bougie is not occasionally passed.

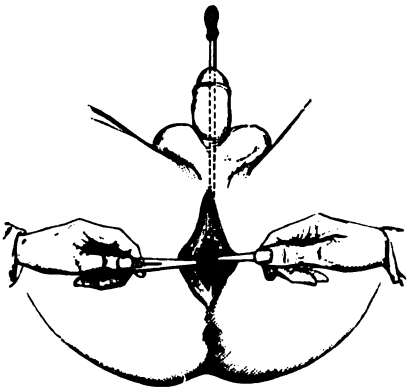


FIG. 512.—Wheelhouse's method of opening urethra.
(Bryant's Surgery.)

Perineal section must not be confounded with Syme's operation, to which this term is sometimes applied. The older operations of perineal section were performed by cutting into the urethra either in front of or behind the stricture, and then trying to divide the stricture without a guide. They were the most difficult operations in surgery. The stricture was often missed altogether and an incision made by its side, and the greatest difficulty was experienced in finding the proximal end of the urethra. Indeed, after a long search the surgeon had often the mortification of having to send

the patient back to bed without having succeeded in reaching the bladder. These difficulties have to a great extent been overcome by Mr. Wheelhouse, who, instead of cutting down upon the end of the staff on the face of the stricture, opens the urethra *half an inch* in *front* of it, and passes a director through the opening thus made in the urethra into the stricture and divides the latter.

Wheelhouse's method of perineal section.—Pass Wheelhouse's staff (Fig. 511), with the groove downwards, to the stricture. Place the patient in the lithotomy position with the pelvis raised so that light may fall into the wound. Make an incision in the middle line of the perineum, and open the urethra on the groove (not on the point of the staff), so as to be *half an inch* in *front* of the stricture. Seize the edges of the healthy urethra on each side by artery forceps, and hold them apart. Withdraw the staff a little, turn it so that the groove looks towards the pubes, and catch up the upper angle of the opened urethra by the hooked end. The urethra is thus held open

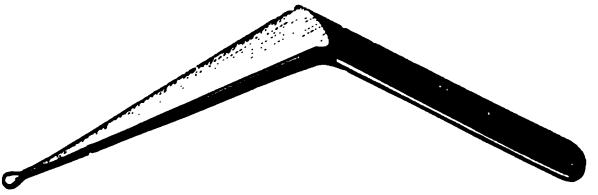


Fig. 513.—Wheelhouse's probe-gorget.

at three points (Fig. 512). Search for the stricture, and pass a slender probe-pointed director through it into the bladder. Divide the stricture with a probe-pointed bistoury run along the groove in the director. Pass the point of the probe-gorget (Fig. 513) along the groove of the director towards the bladder, dilating the divided stricture. Introduce a gum-elastic catheter from the meatus into the wound, and guide it by the gorget into the bladder. Withdraw the gorget, and retain the catheter in the urethra for three or four days. The catheter should allow a catgut bougie to pass through it to act as a guide when it has to be changed.

Cock's operation of perineal section, or tapping the distended urethra at the apex of the prostate "unassisted by a guide staff." Secure the patient in the lithotomy position. Pass the left forefinger into the rectum, and place its point on the apex of the prostate (Fig. 514). Plunge a double-edged scalpel (Cock's knife), or, if preferred, a blunt-backed knife, boldly into the median line of the perineum, and carry it towards the tip of the finger in the rectum. Enlarge the incision by an upward and downward movement of the knife, but do not withdraw it. When the point is felt near the tip of the finger, press it onwards into the urethra. Withdraw the

knife, keep the finger in the rectum, and guide a probe-pointed director into the bladder. Withdraw the finger from the rectum, and pass a cannula along the director into the bladder, and tie it in for a few days. This is a good operation for impervious stricture with retention of urine when the urethra is *distended* behind the stricture. It is also employed for impervious stricture with fistulæ and much induration of the perineum, and for such is held in considerable favour by some of the Guy's surgeons. For these strictures, however, Wheelhouse's operation is more generally performed.

Urethral or urinary abscesses may occur at any part of the urethra, but the most common situation is in the perineum. *Cause.*—They are most often formed in connection with stricture, and are then due to ulceration and local extravasation of urine behind the seat of obstruction. They may also result from injury

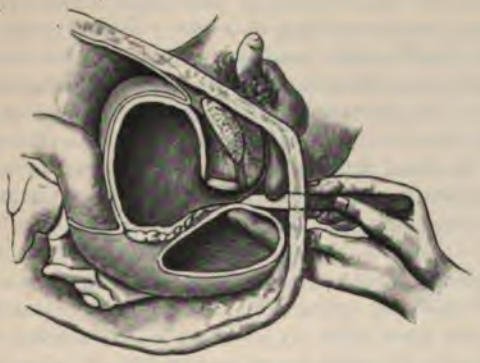


Fig. 514.—Cock's operation of perineal section. (Modified from Bryant's Surgery.)

inflicted either from without or from within, as passing an instrument along the urethra, or the impaction of a calculus; or they may occur during an attack of gonorrhœa from inflammation extending to one of the urethral follicles or to Cowper's glands. The *signs* of a urethral abscess in the perineum, its most common situation, are the presence of a hard, brawny, deeply-seated swelling, generally beginning in the middle line just in front of the anus, and as it increases in size, making its way to one or other side of the perineum in the direction of the groin. At first, while the pus is bound down by the deep layer of the superficial fascia, there is no fluctuation, and it is only as it approaches the surface that this sign of abscess can be detected. The abscess is attended with throbbing pain, often with sharp constitutional disturbance, and occasionally with a rigor; it may also cause retention of urine. *Treatment.*—Fluctuation must not be waited for, but a catheter passed down the urethra, and a free incision made in the median line of the perineum

into the swelling, and the finger passed into the bladder. If the abscess is not opened, it may break externally on the perineum, or it may burrow amongst the tissues and break into the rectum; and if not already in connection with the urethra, as when the abscess forms external to it, it may break into that canal.

Urinary fistulæ are generally the result of urinary abscess in connection with stricture of the urethra. They may also be due to wounds of the urethra, made accidentally, or by surgical operation, or to ulceration following impaction of a calculus. They are of three kinds:—1, The *perineal;* 2, the *scrotal;* and 3, the *penile.* The perineal may be single or multiple; the scrotal are nearly always multiple; and the penile single. In long-standing cases the fistulæ may burrow among the tissues of the groin, nates, and thighs, and may even open into the rectum.

Treatment.—When due to stricture, the fistulæ will generally readily heal when the stricture is cured and a free natural passage is established for the escape of urine. Should they not do so—1. A *perineal fistula*, when small, may be induced to close by passing a soft catheter to prevent the contact of urine whenever the patient micturates, or by inserting into the fistula a hot wire or a probe coated with silver nitrate. If these means fail, the edges of the fistula may be pared and brought together by sutures. When the parts are indurated and the stricture is of the cartilaginous kind, external urethrotomy and laying open of the fistula should be practised. 2. *Scrotal fistulæ* nearly always require freely laying open, and when secondary fistulæ extend to the groin or buttock, they should also be treated in this way; the stricture may be treated at the same time by dividing it by external urethrotomy. 3. A *penile fistula*, when large, and especially when the result of sloughing consequent upon the impaction of a calculus, usually requires a plastic operation. A flap of skin is raised on one side of the fistula; the margins of the fistula are pared, the mucous membrane is invaginated towards the urethra and sutured, and finally the skin flap drawn across the line of union of the mucous membrane and fixed to the skin edge on the opposite side.

Extravasation of urine is commonly, though not always, the result of stricture, and is then due either to the dilated urethra behind a stricture ulcerating and giving way, or to a lacunar abscess bursting into the urethra. In either case, the urine is forced by the contraction of the bladder into the surrounding cellular tissue. The urethra may give way (1) in front of the anterior layer, (2) between the two layers, and (3) behind the posterior layer of the triangular ligament. In the first, and by far the most common, situation, it is the bulbous portion of the urethra that gives way. Here the urine is prevented from passing—1, backwards into the pelvis by the anterior layer of the triangular ligament being attached to the rami of the pubes and ischium and sub-pubic ligament; 2, downwards

into the ischio-rectal fossa by the anterior layer of the triangular ligament being continuous around the transverse perineal muscle with the deep layer of the superficial fascia of the perineum; 3, laterally on to the thighs by the deep layer of the superficial fascia of the perineum being attached to the rami of the pubes and ischium. Hence it passes in the middle line into the cellular tissue of the scrotum and penis, and laterally on to the abdomen, where it is prevented from passing down the thigh by the deep layer of the superficial fascia of the groin (which is continuous with the deep layer of the superficial fascia of the perineum) being attached along the line of Poupart's ligament. When the *membranous portion* of the urethra is ruptured, the urine is confined at first between the two layers of the triangular ligament, and if not let out will make its way (1) forwards, through the anterior layer, and take the course as given above, or rarely (2) backwards, through the posterior layer, and then, as when the urethra gives way behind the posterior layer will make its way around the neck of the bladder, and will almost inevitably cause death. Wherever stale urine spreads, it produces inflammation and sloughing.

Symptoms.—The history of a case of extravasation is not uncommonly as follows. A patient with a tight stricture is straining to pass water, he feels something give way, experiences a sensation of relief, and perhaps owing to the tension being removed by some urine being forced into the cellular tissue, the superadded spasm for a time ceases, and a few ounces of urine are passed through the urethra. In half an hour or so a pricking or burning sensation is felt in the perineum, soon followed by pain and by rapidly increasing swelling of the perineum, scrotum and penis. If the urine is not let out by timely incisions the swelling extends to the groin, and has been known to reach as high as the axilla. The skin now appears dusky or purplish-red and œdematous, and sloughing of the infiltrated tissues rapidly ensues. The absorption of the septic products gives rise to constitutional disturbance and fever; the fever, though it may at first run high, soon assumes a low typhoid character, and the patient, especially if the subject of chronic kidney disease, sinks into a comatose state and dies. When the extravasation occurs between the two layers of the triangular ligament, it may remain localised, giving rise to a hard circumscribed swelling in the perineum, which may slowly make its way towards the scrotum; and lastly, when the extravasation occurs behind the posterior layer of the triangular ligament and the urine is extravasated into the pelvic cellular tissue, the symptoms resemble those of extra-peritoneal rupture of the bladder.

Treatment.—A catheter should be passed into the bladder, or where this is impossible, down to the stricture, and in either case a free incision in the middle line of the perineum extending into the urethra made on the catheter. Free incisions through the skin of

the scrotum, penis, and groins, in fact, wherever the urine has penetrated, should likewise be made to allow of its draining away, and the wounds rendered as far as possible aseptic by the free application of antiseptic lotions. The patient's strength at the same time must be supported by fluid nourishment and stimulants, and opium given, unless contra-indicated on account of kidney disease.

Stone in the urethra.—A small calculus or fragment of one may become impacted in any part of the urethra, but most frequently in the membranous portion (Fig. 515), or just within the meatus. When sharp and angular it causes much pain, and when large enough to obstruct the urethra gives rise to retention, and, if not soon removed, to ulceration followed by extravasation of urine. *Treatment.*—If far forward, it may often be expelled, whilst the patient is straining to pass water, by holding the meatus and suddenly letting go; or gentle manipulation, aided, if necessary, by a downward incision of the meatus, may suffice. Extraction by urethral forceps (Figs. 516 and 517) should next be tried, but with the greatest gentleness for fear of lacerating the urethra; it is much better to cut into the urethra than to lacerate it with forceps. The forceps failing, a free incision over the stone must be made. Thus, if impacted in the membranous portion, it should be removed through an incision in the middle line of the perineum; if in the penile portion just in front of the scrotum, it should be pushed back if possible into the membranous portion and removed through the perineum, as an incision in the penile portion of the urethra is apt to be followed by a fistula, and should therefore be avoided. If compelled to incise the penile urethra the incision should be free so as to prevent laceration of the tissues in extracting the stone. The edges of the wound should then be united by suture, and a soft catheter tied in the urethra for a few days till the incision has healed.

FIG. 515.—Calculus impacted in urethra. (St. Bartholomew's Hospital Museum.)

Retention of urine, or inability to pass water, must be distinguished from suppression of urine in which none is secreted. *Cause.*—Retention may depend upon either (*a*) obstruction to the outflow of urine from the bladder, or (*b*) inability of the bladder to expel its contents consequent upon atony of its muscular coat or paralysis. Retention, therefore, is a symptom of several diseases. 1. In *the old*, it is commonly due to enlarged prostate with superadded congestion, combined with atony of the bladder from overdistension. 2. In *adult men* it may be due to organic stricture with

temporary spasm of the unstriped muscular fibres of the urethra, or to congestion of the mucous membrane owing to gonorrhœa, a drinking bout, or cold and wet. 3. In *women* it may be the result of hysteria, or the pressure of an enlarged uterus or other pelvic tumour or of the fœtal head in parturition. 4. In *children* it is commonly caused by an impacted calculus or ligature of the penis, and more rarely by phimosis. 5. At *all ages* and in *both sexes* it may be due to reflex spasm after an operation on the rectum, shock following any severe injury or operation, a tumour at the neck of the bladder or urethra, and an abscess involving any part of the urethra.

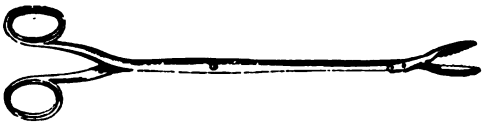


Fig. 516.—Urethral forceps (Arnold's).

It may also be due to paralysis consequent upon disease or injury of the brain or spinal cord, and to atony of the muscular coat of the bladder. In the two latter conditions, however, after the bladder has become distended and will hold no more, the excess of urine passively overflows, dribbling constantly away; and this condition of false incontinence must be distinguished from true incontinence, in which the urine runs away from the bladder as fast as it is secreted by the kidneys.

Symptoms and signs.—When retention has come on slowly, as from the gradual contraction of an organic stricture, there may

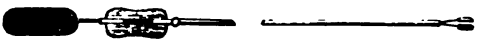


Fig. 517.—Hogan's urethral forceps.

be but little local pain and no constitutional disturbance, even although the bladder may be distended by many ounces of urine. Where, however, it is produced suddenly, there is usually great pain followed by severe constitutional symptoms—a small and frequent pulse, a dry and brown tongue, and perhaps delirium, symptoms probably due to the sudden check to secretion by the kidneys, and to the stretching of the bladder. The bladder itself, unless greatly hypertrophied and contracted, rises out of the pelvis, and may be felt as a distinct tumour, dull to percussion, and at times extending as high as the umbilicus, or in extreme cases even to the ensiform cartilage. The patient, unless drunk, usually complains of inability to pass water. When, however, the bladder has become gradually distended and urine is passively flowing away, he may complain of inability to hold his water, and be quite unaware

that the bladder is full, and may object to have a catheter passed till the condition has been explained. The presence of a swelling in the abdomen, and the flowing of urine through the catheter immediately after the patient has passed water and believes that he has emptied his bladder, should serve for the diagnosis. In suppression, the bladder is found empty on passing a catheter.

Results of retention.—If the bladder is soon relieved no apparent harm may ensue. If neglected, however, the over-distension may lead to—1, atony of the muscular coat; 2, cystitis; 3, nephritis; 4, rupture of the urethra behind the obstruction; 5 (rarely), rupture of the bladder itself; and, 6, passive overflow of urine, the bladder remaining full.

Treatment.—The distended bladder must be relieved, and if the distension is extreme and the symptoms urgent, at once. The way of doing this will vary according to the cause, and will be considered under the following heads:—

1. *Retention from spasm of the unstriped fibres surrounding* the urethra, sometimes called *spasmodic stricture*. Spasm is rarely, if ever, sufficient, alone, to cause retention, some organic narrowing of the urethra being nearly always present. The usual history of retention from spasm is a drinking bout, or exposure to cold or wet in a gouty or rheumatic subject; while, on careful questioning, the patient admits that the stream has been noticed to be small or forked, or that a similar attack of retention has previously occurred. If the retention has existed for some time, and there is much pain and considerable distension of the bladder, a flexible catheter (No. 8 or 9) should be passed, if necessary under chloroform. When, however, the symptoms are not urgent, and an instrument has never been passed, a hot bath and a full dose of tincture of opium will generally suffice. In retention due to spasm following operations, a well-lubricated soft-rubber catheter should be passed.

When the spasm is associated with a severe organic stricture other means may have to be taken. See *Treatment of Retention from Organic Stricture.*

2. *Retention from congestion of the mucous membrane* of the urethra, sometimes known as *congestive stricture*. Congestion, like spasm, is seldom sufficient of itself to produce retention; and is nearly always associated with at least a slight organic stricture or with some enlargement of the prostate. It is usually the result of gonorrhœa, or other conditions causing inflammation of the urethra. The treatment is that of retention from spasm.

3. *Retention from hypertrophy of the prostate* (see p. 1001) occurs only after middle life. It is then generally due to congestion induced by cold, the abuse of alcohol, etc., causing the already existing obstruction to become complete. First, try to pass a No. 9 silk coudé catheter (Fig. 500), then a double coudé (Fig. 501), and these failing, a gum-elastic catheter with a large curve. Should

the point hitch at the middle lobe of the prostate, withdrawing the stylet for half an inch will cause the end to slightly tilt up, and it will then often readily glide into the bladder. If not successful in this way, the silver prostatic or the beaked catheter must next be tried, but serious mischief may be done by these instruments unless the greatest gentleness is used. They should never be employed until other forms have failed. If a catheter passes easily it may be withdrawn after the bladder is relieved; but if passed with difficulty it had better be left in, as more harm may be done by having to pass it again than by leaving it *in situ*. When the bladder is greatly distended all the urine should not be drawn off at once, lest syncope be induced, owing to the sudden descent of the diaphragm and diminished pressure on the abdominal veins. A catheter failing, the retention may be relieved by: 1, puncture above the pubes; 2, puncture through the rectum; and 3, forcing a catheter through the prostate (*tunnelling*). The first method is decidedly the best. The second is seldom applicable, as the enlargement, as a rule, leaves no room between the prostate and the pouch of peritoneum for puncture, which, if attempted, will probably wound the peritoneum. The third method is attended with extreme danger, and is seldom practised at the present day (see p. 1004).

4. *Retention from organic stricture.* — The symptoms and diagnosis of stricture have already been described. Here only need be mentioned the treatment to be adopted in cases of retention from this cause. An endeavour should first be made to pass a catheter, if necessary under an anæsthetic. If this fails, and the symptoms are not urgent, a hot bath and a full dose of tincture of opium may be given, and another trial made in a few hours. Where, however, there are signs of grave kidney disease, opium must be withheld or given with great caution. Should these means not succeed, or if from the first the symptoms are urgent, one of the following methods may be resorted to, viz.: 1. Aspiration, or puncture of the bladder above the pubes; 2. Wheelhouse's operation; 3. Puncture of the bladder through the rectum; 4. Cock's operation of opening the urethra behind the stricture through an incision in the perineum; and 5. Harrison's operation of puncture through the perineum. *Aspiration* above the pubes, repeated, if necessary, should the stricture not quickly yield after the spasm has been removed by emptying the bladder and thus reducing the tension, is, as a rule, attended with excellent results. It is not, however, absolutely free from danger. Thus it should not be practised when the urine is unhealthy, or the walls of the bladder are thin and atonied, lest a drop or two escape through the puncture into the pelvic cellular tissue, and set up septic inflammation and suppuration, which may be followed by extravasation of urine. *Puncture through the rectum* is strongly

recommended by some surgeons; but it is open to the objection that suppuration between the bladder and rectum, extravasation of urine, cystitis, and a permanent recto-vesical fistula, are liable to follow, to say nothing of the annoyance to the patient from the presence of the cannula in the rectum, and the excoriation of the parts by the urine, which, notwithstanding care, is apt to occur. The vas deferens, moreover, may be injured, and atrophy of the testicle ensue. *Cock's operation* (p. 1024) is an excellent one, but difficult to perform, unless the urethra behind the stricture is distended with urine. *Harrison's operation* is best adapted to cases in which the stricture is in the membranous urethra, or the obstruction is due to prostatic enlargement. Should the passage of a catheter not be effected after the bladder has been aspirated on several occasions, Wheelhouse's operation (p. 1024) should be undertaken.

5. *Retention from hysteria* should be combated by such moral and physical treatment as is applicable to that disease. A catheter should not be passed if it can be possibly avoided. A hot sponge applied above the pubes and a smart purge is usually successful.

6. *Retention from paralysis or atony of the bladder, from abscess or tumour of the urethra or bladder, from impacted calculus, and from ligature of the penis,* is discussed under the heads of *Paralysis of the Bladder, Impacted Calculus, etc.*

Puncture of the bladder above the pubes (Fig. 407, B).—Make a small incision through the skin immediately above the pubes, having first ascertained by percussion that the bladder has risen well out of the pelvis, and thrust Cock's curved trocar and cannula downwards and backwards into the bladder. Withdraw the trocar, secure the cannula *in situ*, and pass through it a soft catheter connected with a long rubber tube to carry away the urine. In a few days, when the parts are consolidated, the cannula should be changed. When the bladder is distended, a good inch rises above the pubes uncovered by peritoneum, but when contracted and hypertrophied it may rise but little if at all. Under these latter circumstances the trocar and cannula must be passed close to the pubes for fear of wounding the peritoneum.

Aspiration is performed in a similar way, except that the aspirating needle or trocar is thrust in without any preliminary incision of the skin. If a small aspirating needle or cannula is used there is no danger of extravasation, as on its withdrawal the puncture in the bladder is closed by the contraction of the muscular fibres; and even should a drop or two of urine escape no harm will ensue provided the urine is healthy. It is a most useful emergency operation, and, if necessary, may be repeated on several successive occasions. If the urine is ammoniacal and loaded with pus it should not be performed.

Puncture of the bladder through the rectum.—Place the

patient in the lithotomy position. Pass the left forefinger into the rectum, and place its tip just beyond the back of the prostate. Take Cock's long curved trocar and cannula, with the point of the trocar slightly withdrawn within the cannula. Introduce it through the anus, and guide it by the finger in the rectum to a spot immediately behind the prostate, exactly in the middle line. Press the cannula firmly on the bulging trigone of the bladder, and plunge the trocar boldly into the bladder, in a direction upwards and forwards towards the umbilicus Withdraw the trocar and secure the cannula *in situ* with suitable tapes. Do not plug the cannula, but fix an india-rubber tube on its end, and convey this to a vessel beneath the bed. The objections to this operation have already been stated (p. 1031).

Puncture of the bladder through the perineum (*Harrison's operation*).—With the patient in the lithotomy position, place the left index finger in the rectum and introduce a long straight trocar and cannula in the middle line of the perineum about three-quarters of an inch in front of the anus and push it steadily through the prostate, guided by the finger, into the bladder. Withdraw the trocar and fix a rubber tube on the end of the cannula to convey the urine into a utensil. The advantages claimed for the operation are a dependent drain and a convenient position for the external opening. When in consequence of vesical irritation a permanent opening is desired, Harrison advises that a sound should be passed into the bladder, its beak turned down behind the prostate into the post-prostatic pouch and the point of the trocar directed against it.

Diseases of the Male Genital Organs.

Diseases of the Penis.

Paraphimosis is the strangulation of the glans penis by a tight prepuce which has been drawn back over it, and cannot be replaced. Thus, it is not infrequently met with in boys, from the accidental uncovering of the glans and neglect to draw the prepuce forward again. In adults it is generally due to swelling, caused by gonorrhœa or venereal sores, but it may occasionally occur during coitus. It is attended with great œdema of the glans and prepuce, and if not soon reduced may lead to ulceration at the line of constriction, or even to sloughing of the penis. *Treatment.*—Seize the penis between the first and second fingers of each hand, press the blood and œdema out of the glans with the thumbs, and at the same time push the glans backwards and try to draw the prepuce forward over it. If this fails, divide with a knife (Fig. 518) the constricting band, which is formed by the orifice of the prepuce, and which lies just behind the fold of the œdematous mucous

lining of the prepuce at the bottom of the furrow on the dorsum of the penis, taking care to avoid the subcutaneous veins, lest extensive subcutaneous extravasation of blood follow.

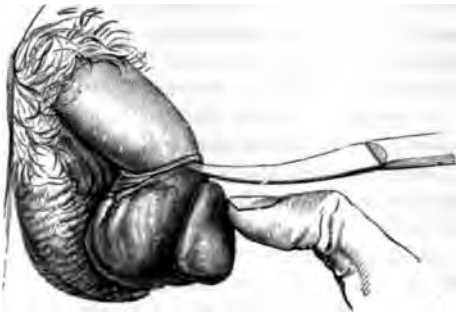


FIG. 518.—Method of dividing the stricture in paraphimosis. (Bryant's Surgery.)

Phimosis is a condition in which the prepuce is elongated, and its orifice contracted, so that it cannot be drawn back over the glans. It may occur as a congenital affection; or it may be acquired, and is then usually due to the cicatricial contraction of the orifice following syphilitic ulceration or repeated attacks of gonorrhœa.

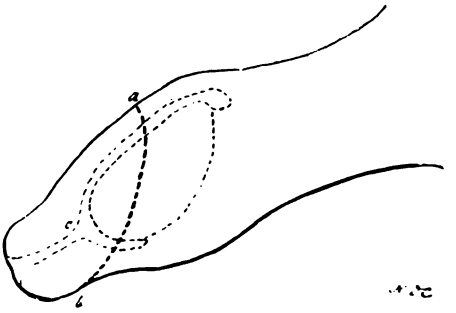


FIG. 519.—Davies-Colley's incision in performing circumcision. *a b*. Line of incision for removing prepuce. *c*. Point of constriction of the mucous membrane which causes phimosis. The fine dotted line indicates position of the mucous membrane lining the prepuce and reflected over the glans. (Guy's Hospital Reports.)

The orifice when very small may cause difficulty of micturition or even retention of urine; whilst the straining to pass water may induce prolapse of the rectum, hernia, irritation of the bladder and symptoms of stone, nocturnal incontinence, and sometimes even hæmaturia or symptoms of hip disease or spastic contraction of the lower limbs, and if not relieved may produce the harmful effects on

the urinary organs described under *Stricture;* or the deposit of the urinary salts beneath the prepuce may lead to the formation of preputial calculi. The inability to uncover the glans may cause pain and difficulty in coitus, impotence or sterility, and, by preserving a mucous membrane-like character to the glans, predispose to venereal disease; whilst the secretion which collects beneath the prepuce may, in consequence of the irritation it is apt to set up, induce priapism, habits of masturbation, inflammation sometimes simulating gonorrhœa, adhesion of the glans to the prepuce, retention of urine and pressure backwards on the bladder and kidney, or even as age advances to elephantiasis or the formation of an epithelioma. The *treatment* may be considered under the heads of—1, *circumcision;* 2, *slitting the prepuce;* and 3, *dilatation of the preputial orifice.*

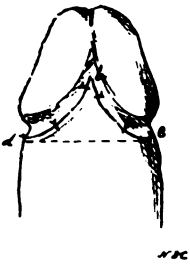


FIG. 520. — Davies-Colley's method of circumcision. *b.* Pointed flap of skin filling up triangular interval *b d e* which is left on removing the mucous membrane of the frenum. This interval, if not thus closed, heals slowly by granulation.

1.—*Circumcision.*—Having separated the prepuce from the glans as much as possible with the fingers or a probe, lay hold of it with circumcising forceps, on a level shown by the line *a b* in Fig. 519. Let the glans slip back, close the forceps, and shave off the prepuce in front of them with a clean sweep of the knife. The advantage of this incision is that a pointed flap of skin is left on the under surface of the penis and fills up the triangular interval that results when the mucous membrane forming the frenum is subsequently removed (Fig. 520). Remove the forceps, slit up the mucous lining of the prepuce in the middle line quite to but not beyond the corona, break down any adhesions between the prepuce and glans, wash away the secretion, remove the mucous membrane to within an eighth of an inch of the corona, twist or tie any spurting vessels, and stitch the remaining frill of mucous membrane to the skin with interrupted horse-hair or cat-gut sutures (Fig. 521). In infants no sutures are required. Dress with iodoform gauze. Remove dressing in bath in case of infants or young children, and redress with boric acid ointment or aseptic gauze. After circumcision the meatus is apt to

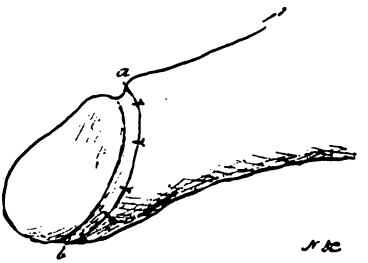


FIG. 521. — Davies-Colley's method of circumcision. *a b*, Line of union when the skin edge is stitched to the frill of mucous membrane.

become contracted and give rise to reflex irritation. If found small at the time of the operation or subsequently, it should be enlarged by an incision in a downward direction.

2. *Slitting the prepuce* may be done with scissors, or with a curved bistoury guided by a director, introduced between the glans and prepuce. In either case the mucous membrane should be united to the skin-flaps by fine sutures after twisting or tying any bleeding vessels. Care should be taken not to pass the director into the meatus, and to ensure that the mucous membrane is slit quite back to the corona. This operation is very inferior to circumcision, and should rarely be employed.

3. *Dilatation of the prepuce* may be accomplished in slight cases by a daily endeavour to draw back the contracted prepuce over the glans. It may also be done by the preputial dilator, or by forcible separation of the blades of the dressing forceps, though such means are not often successful. Circumcision is much better.

Circumcision should be performed—1. If the preputial orifice is greatly contracted; 2. If the prepuce is very long; 3. If inflammatory changes are occurring beneath it; 4. If it is adherent to the glans so that it cannot be retracted; 5. If any of the usual sequelæ, as hernia, prolapse of the rectum, etc., are present.

Primary venereal sores or chancres.—Two chief varieties of venereal sore or chancre occur, *the syphilitic* or *infecting*, and the *local contagious* or *non-infecting*. Either of these may be accompanied by sloughing or phagedæna, and is then spoken of as a sloughing or phagedænic sore or chancre.

1. *The primary syphilitic chancre* has already been described in the section on *Syphilis* (p. 75).

2. *The local contagious* or *non-infecting sore*, the *soft chancre* or *chancroid*, as it is sometimes called to distinguish it from the hard or syphilitic chancre, is described at p. 71.

Diagnosis.—The main differences between a non-infecting or soft sore, and an infecting or hard, are the following: The soft sore is generally unattended with induration; in the hard the induration is generally well marked. The soft occurs within a few days of inoculation; the hard not till after three to five weeks. In the soft the secretion is abundant and purulent; in the hard scanty, and often consists of little more than epithelial débris. The soft can be re-inoculated on the same patient, and hence is frequently multiple; the hard cannot be re-inoculated on the same patient, and hence is single unless, as very rarely happens, the patient is inoculated in two places at the same time. The bubo following the soft sore is often single, at first brawny, then soft, and very liable to suppurate. That following the hard sore is multiple, hard, and the glands almond-shaped; it very rarely suppurates. A patient, however, may be inoculated with syphilis at the same time that he receives a soft sore. Hence, when the incubative period of syphilis has

passed, the soft sore may take on the characters of the hard sore. Till this period is over, therefore, a cautious prognosis as to the probable occurrence of secondary symptoms should be given. It is consequently not uncommon to find a patient with a chancre which presents characters both of the hard and soft sore. A soft sore must also be distinguished from a crop of hepetic vesicles. The latter are small, numerous, and grouped close together, there is usually a history of repeated attacks, and but very slight or no enlargement of the inguinal glands.

Treatment.—Local treatment only is necessary, and consists in scrupulous cleanliness, protection of the sore from irritation, and the application of black-wash, zinc lotion, or iodoform. Should the glands become inflamed, rest in the recumbent posture is essential. If suppuration threatens, boric acid fomentations must be applied, and a free incision made. Should any intractable sinuses, as frequently happens, be left after the bubo has suppurated, they should be laid freely open, and allowed to granulate from the bottom.

3. The *sloughing sore* is due to want of cleanliness or the retention of irritating discharges by a long foreskin, and generally occurs in weakly or debilitated subjects. The sore, which is covered with a yellow slough, and is surrounded by an angry areola of inflammation, spreads rapidly, and is attended with considerable swelling and œdema of the penis. The general appearances of the ulcer and its appropriate treatment have already been given in the section on *Ulcers* (p. 34).

4. The *phagedænic sore.*—Phagedæna may attack both the hard and soft sore, but is said by Mr. Hutchinson to be a more frequent complication of the former than of the latter. Like the sloughing sore, it may be due to want of cleanliness and neglect, or to the irritation of the discharges retained by a long foreskin. It seldom, however, occurs to any serious extent, except in those whose constitutions are broken down by want of food, abuse of alcohol, debauchery, or exhausting disease. For a description of the characters and treatment of this ulcer see p. 34.

Induration of the corpora cavernosa.—The corpora cavernosa are subject to painful induration, which hinder and distort the penis in erection. This induration may be of gonorrhœal origin, a marked form of chordee, or due to a gummatous induration or to gout. A steadily-increasing mass may prove to be a sarcoma. *Treatment.*—Mercury ointment covered with lint is applied each night, iodide of potassium administered, also morphine suppositories and bromide of potassium, for painful erections. If the induration progresses, the penis must be amputated.

Elephantiasis of the penis.—The organ is much enlarged by thickening of the skin and subcutaneous tissue, as the result of filariasis (see p. 113) or of repeated attacks of venereal disease in a patient with phimosis. For treatment see *Elephantiasis Scroti.*

Epithelioma of the penis generally begins as a warty growth or as an ulcer on the glans or inner surface of the prepuce. Old age is looked upon as the chief predisposing, and the irritation of retained secretion under a long prepuce as the common exciting cause. The indurated, sinuous and everted edges of the ulcer, the warty base, sanious and foul discharge, rapid growth, advanced age of the patient, and later, the involvement of the inguinal glands, will generally serve to distinguish it from warts or venereal ulcers, for which it may be mistaken. If allowed to run its course, the whole penis becomes infiltrated with the growth; the lumbar, as well as the inguinal glands, become involved; sloughing and ulceration ensue, and the patient generally dies of exhaustion or hæmorrhage. The internal organs are not usually affected. *Treatment.*—If seen early, the growth alone may be excised, together with the inguinal glands, although they may apparently be unaffected. As a rule, however, the penis should be amputated in front of the scrotum. If the disease extends backwards to the scrotum the latter structure may, under certain conditions, be split, the whole penis, with the crura, removed, and the urethra stitched to the perineum. If the glands are extensively involved and have implicated the femoral vessels no operation should be done.

Amputation of the penis.—*In front of the scrotum.* A dorsal skin-flap is raised, half the circumference of the penis in length and breadth, and the remaining skin divided transversely on a level with the base of the flap. The corpora cavernosa are next cut through at the same level, and the corpus spongiosum three-quarters of an inch in front. The urethra is now dissected out of the corpus spongiosum, and, after bleeding vessels have been tied, is passed through a vertical elliptical incision in the centre of the dorsal flap. The flap is united to the skin on the under aspect of the penis by sutures. The end of the urethra projecting through the incision in the flap is slit vertically and horizontally, and the four pieces stitched to the flap. The raw surface of the stump is thus completely covered in, and union by the first intention occurs. A catheter is passed and made to project through the dressings. Hæmorrhage during the operation is restrained by the fingers of an assistant. The two dorsal arteries and the arteries of the corpora cavernosa and of the septum usually require ligature.

On account of the retraction of the stump, which sometimes occurs if a sufficiently long piece of the urethra is not left, and the diminished expulsive power in old patients, with slight prostatic hypertrophy, it may occasionally be advisable to dissect up the urethra and fix it in the perineum. Then the penis is cut off in front of the scrotum, and the scrotal portion of the urethra in front of that fixed in the perineum is bluntly separated, the raw surfaces of the corpora cavernosa sutured together to arrest hæmorrhage, and the skin united over the stump. A rubber catheter is passed into

the bladder, through the perineum, and the urine conducted into a vessel under the bed for a day or two, after which the patient passes urine readily on a bed-pan, and later has to do so in a sitting posture (the great objection to this method). The inguinal glands must be closely watched, and excised on the first sign of enlargement.

Excision of the whole penis. — A sound is passed into the bladder, and the patient placed in the lithotomy position. The scrotum having been split and the incision carried over the root of the penis, the corpus spongiosum is dissected off the corpora cavernosa as far as the triangular ligament, and is then divided, leaving the proximal portion long enough to protrude from the lower end of the external wound. The suspensory ligament is next severed, the dorsal vessels tied, and the crura of the corpora cavernosa separated from the ischio-pubic rami with a raspatory. The external wound is now closed except below where the urethra is brought out. The fixation of the urethra is facilitated, and its subsequent contraction prevented, by splitting the end in the way described above. If the inguinal glands are enlarged, the incision round the root of the penis should be prolonged upwards to the groin, so that the glands, together with the lymphatic vessels running to them, may be removed in one piece. Some surgeons recommend that castration should be performed at the same time.

DISEASES OF THE SCROTUM, SPERMATIC CORD, AND TESTICLE.

Epithelioma of the scrotum, often called *chimney-sweep's* cancer, from the frequency with which it occurs in chimney-sweepers owing to the irritation of the soot, generally begins as a dark wart or tubercle, which ultimately ulcerates, producing a sore with hard sinuous everted edges, and an irregular warty tuberous base. In some instances ulceration is delayed and the cancer takes the form of a typical cauliflower-like growth. At times it begins as a chronic eczema. The irritant would appear to be not merely the carbon of the soot, but one or more of the products of the destructive distillation of coal, as the cancer does not occur from soot produced by the burning of wood, and is found amongst workers in coal-tar and its products. The inguinal glands become enlarged early, at first from inflammatory infiltration, later from invasion by the epithelial growth, but the disease does not, as a rule, affect internal organs. The testicle may occasionally become involved, when the lumbar glands will be, sooner or later, affected. Death is commonly due to the exhaustion and septic poisoning caused by the ulceration in the inguinal glands, or haemorrhage from the opening of a large blood-vessel in the groin. *Treatment* — Free and early excision with the knife, and removal of the inguinal glands if enlarged and hard. If the testicle is involved it should be removed at the same time. The skin of the part is very thin and although

the testicle may be denuded, it, as a rule, rapidly becomes covered in. If there is not sufficient skin, the testicle must be removed. When a deep dissection is necessary for the removal of the disease, a staff should be placed in the urethra to avoid injuring that canal.

Œdema of the scrotum, owing to the laxity of the tissues, is common. It may occur in kidney and heart disease as part of the general dropsy, or it may be caused by inflammation of the neighbouring parts, as the testicle. It is also met with in extravasation of urine, and may occur after an operation for hernia, varicocele, etc.

Erysipelas of the scrotum may be the result of slight injuries, abrasions, etc. It is attended with great swelling, and œdema, but with little or no redness, and is very liable to terminate in extensive sloughing and gangrene. The same general and local treatment should be adopted as described under *Erysipelas*, with free and early incisions should suppuration threaten.

Eczema and **prurigo of the scrotum** require no special mention.

Elephantiasis scroti is an enormously hypertrophied condition of the skin and connective tissue of the scrotum, the result of filariasis. The scrotum may enlarge to the size of the head, or hang down to the knee as a pear-shaped tumour, or, larger still, may touch the ground, and the patient have to move with the mass supported on a go-cart or wheelbarrow. The swelling consists of œdematous fibrous tissue in which may develop cysts or multiple abscesses, and contains two cavities, the tunicæ vaginales testis. As the tumour grows the testicles attached by the remains of the gubernaculum testis are likewise pulled down and the cord is enormously lengthened. The fluid in the tunica vaginalis may be serous or chylous, or it may become purulent. The skin is rugous, ulcerated, or may leak lymph or chyle (lymph scrotum). The penis is dragged down and urine dribbles out of a depression on the front of the mass. The progressive enlargement is frequently added to by intercurrent attacks of inflammation. Elephantiasis of the penis or of the clitoris is similarly produced.

Treatment.—A time is selected when the patient is free from fever and the mass is elevated, *e.g.*, by means of pulleys, for some hours. An elastic band is then tied tightly round the base and kept from slipping forwards by skewers transfixing the pedicle. Flaps are turned up of healthy skin, and the penis and testicles are dissected out, the mass cut away, vessels tied, and a dressing of gauze packed between the flaps over the testicles and penis which soon become covered with skin.

Hydrocele is a collection of serous fluid in connection with the testicle or spermatic cord.

I. **Hydroceles in relation with the testis.**

A. *The fluid is contained within the tunica vaginalis.* Of this form there are four varieties. (1) *The common or vaginal hydrocele*

in which the normal tunica vaginalis is simply distended with serous fluid. This form may be either acute or chronic. (2) The *congenital hydrocele* in which the fluid is contained in an unobliterated

Fig. 522.—Elephantiasis scroti in a Fiji Islander. Weight 90 lbs. Copied by kind permission from Dr. J. B. Hamilton's article in the International Text Book of Surgery.

funicular process of the tunica vaginalis communicating with the general peritoneal cavity. (3) The *infantile hydrocele* in which the tunica vaginalis proper and part of the funicular process is distended

with fluid as far as the external abdominal ring, the funicular process in the inguinal canal having been obliterated. Of this form there is a sub-variety, the *hydrocele en bissac* in which the funicular process has been obliterated at the internal abdominal ring and is contracted at the external ring so that there are two sacs continuous with each other by a narrow neck. (4) The *inguinal hydrocele* in which the tunica vaginalis is distended with fluid around the testicle retained in the inguinal canal. The sac generally communicates with the peritoneal cavity.

B. *The fluid is not contained in the tunica vaginalis.* Of this form there are two varieties: (1) *The encysted hydrocele of the epididymis* in which the fluid is contained in a sac connected with the epididymis. (2) *The encysted hydrocele of the testis* in which the fluid is contained in a space between the tunica albuginea and the tunica vaginalis.

II. **Hydroceles in relation with the spermatic cord.**—Two varieties are described: (1) *Diffuse hydrocele of the cord*, which is nothing more than a localised œdema of the connective tissue of the cord. (2) *Encysted hydrocele of the cord* in which there is a distinct sac containing fluid and arising either (*a*) in connection with an unobliterated portion of the funicular process of the tunica vaginalis, or (*b*) in connection with some persistent remains of the genital portion of the Wolffian body, viz., the paradidymis of Waldeyer or organ of Giraldès.

Common or vaginal hydrocele is a collection of serous fluid in the cavity of the tunica vaginalis.

Causes.—Infancy, middle age, heredity, gout, and malaria are said to predispose to it; whilst slight injuries, repeated strains, the presence of loose bodies in the tunica vaginalis, and certain chronic diseases of the testicle are sometimes exciting causes. Often, however, no apparently efficient cause whatever can be discovered. A collection of fluid in the tunica vaginalis is common in connection with gonorrhœal epididymitis, a contusion of the scrotum or punctured wound of the tunica vaginalis, and is then spoken of as acute vaginal hydrocele. It usually subsides in a few days with the disease or injury to which it is secondary. The chronic form may occur in syphilitic disease of the testis (Fig. 529, p. 1056).

Pathology.—By some it is looked upon as a passive dropsy, due to a loss of balance between the secreting and absorbing power of the tunica vaginalis; by others it is believed to be due to chronic inflammation. The fluid is of a pale straw colour, with a specific gravity of 1,020 to 1,030, and contains a large quantity of albumen. The dilated tunica vaginalis is usually thin; but in long-standing cases it is occasionally greatly thickened, and may be of cartilaginous consistency. The coverings are the same as those of the testicle, viz., skin, superficial fascia, dartos, and intercolumnar, cremasteric and infundibuliform fasciæ.

Symptoms.—Ordinary hydrocele forms a smooth, tense, elastic or fluctuating swelling in the scrotum, of a pyriform, globular or oval shape, and is frequently slightly constricted at its middle or at its lower or upper part. The chief diagnostic sign is its translucency. If the walls are very thick it may appear opaque when examined for translucency in the usual way by the light of a candle; but we have never met with a hydrocele, however thick its walls, which was not found translucent when a powerful light, as that of an electric bell-lamp, was used. The cord is free, and there is no impulse on coughing, signs which serve to distinguish it from a hernia. When the hydrocele extends up the funicular portion of the tunica vaginalis into the inguinal canal there may, however, be a transmitted impulse from the abdominal wall; it might then be mistaken for an irreducible hernia. The dulness on percussion, the history that it began at the bottom of the scrotum, and the translucency, if the light be powerful enough, will distinguish it. The translucency

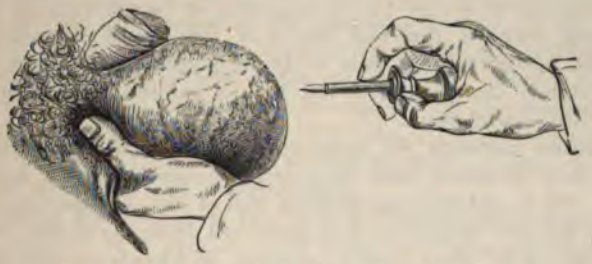


FIG. 523.—Tapping a hydrocele. (Bryant's Surgery.)

must not be relied upon entirely, since an enterocele in an infant containing only empty intestine is translucent, and if strangulated, would, like a hydrocele, be irreducible, and give no impulse on crying. An hydatid cyst in the tunica vaginalis would also be translucent. The testicle is situated behind and near the lower part of the hydrocele, save in exceptional cases where adhesions have been contracted to the anterior wall or the testicle has descended retroverted.

The *treatment* may be palliative or radical. *Palliative treatment* consists in tapping the hydrocele with a trocar and cannula, and repeating the operation from time to time as required. Before tapping a hydrocele the situation of the testicle should be made out, lest it be injured by the trocar. This can usually be done by marking the opaque spot whilst examining for translucency, and by the patient's sensation on handling it. If the sac is not very tense the testicle can be felt. Choose a spot for puncture on the front of the swelling, free from scrotal veins, which can readily be seen through the skin, and having made out the situation of the testicle,

grasp the tumour from behind with the palm of the hand so as to make it tense, and plunge the trocar and cannula, held as in Fig. 523, sharply into the sac to ensure perforating the wall. The trocar should be directed at first backwards, and then immediately turned upwards to avoid wounding the testicle. Having withdrawn the fluid, remove the cannula, and apply a small pad fixed by collodion or strapping.

A cure is sometimes effected by injecting tincture of iodine into the sac through the cannula after having withdrawn the fluid. The quantity injected is usually about two drachms. If ten drops of a 5 per cent. solution of cocain are injected before the iodine no pain generally is felt at first, but as the effect of the cocaine wears off, intense pain, lasting for an hour or more, is often experienced. Injections of ʒj. of pure carbolic acid or of perchloride of mercury (1 in 2,000) into the emptied sac appear to be equally effective. The injection sets up some amount of inflammation and pain, often severe, and cures by restoring the balance between the secreting and absorbing power of the tunica vaginalis, or occasionally by causing adhesions between the two layers of the tunica vaginalis. The injection, however, often fails, or there is recurrence after a year or two. Rarely the patient is left with a painful testis surrounded by indurated scar tissue.

Operative measures for hydrocele.—The sac may be laid open, its surface scrubbed, and then sewn up except for a dependent drain. Or in addition, the parietal wall of the sac may be excised, or the sac and testis are first separated from the dartos, then the sac is slit up its whole length, reflected backwards on each side and the edges sutured together behind the epididymis. By this inversion of the sac all the serous membrane is in contact with the raw inner surface of the dartos. Another method recently introduced is to make a small opening in the sac, and when the fluid has escaped to turn out the testicle, thus leaving it outside the sac walls. Each of these methods has been followed by recurrence. The only absolutely certain method is to lay the sac widely open, cut away as much as possible of the parietal wall, and firmly plug the cavity with gauze, changed at each dressing to ensure that it granulates up from the bottom. It is especially indicated when the wall has become much thickened.

The hydroceles so frequently seen in young children generally undergo a spontaneous cure, and nothing beyond an evaporating lotion is usually necessary. Should the hydrocele prove intractable, however, it may be punctured with a fine trocar and cannula, and, if necessary, afterwards injected with a weak solution of iodine. If this fails, it may be dissected out. A persistent swelling may prove to be tuberculous.

Congenital hydrocele is a collection of fluid in the sac of the tunica vaginalis, the funicular process of which through an arrest

of development has remained unobliterated. The fluid, therefore, unless the aperture of communication is very small, can be readily pressed back into the abdominal cavity, and an expansile impulse is given to it on coughing or crying. In this respect it resembles a congenital hernia, as it does also by coming on slowly shortly after birth, and by occupying the inguinal canal, as well as the scrotum; but its translucency, dulness to percussion, regularity of outline, uniform feel, and the fact that the fluid goes back slowly when pressed upon, and without the sudden slip or gurgle as is the case in a hernia, should serve to distinguish it. It should not be forgotten that a piece of omentum or intestine may descend into the sac of the hydrocele. At times, the aperture of communication between the funicular process and the general peritoneal cavity is closed, and though the hydrocele may still extend more or less up the inguinal canal, the fluid cannot be pressed back into the abdominal cavity. To this condition the name of *infantile hydrocele* has been given.

Treatment.—A truss should be applied over the inguinal canal to promote the obliteration of the funicular portion of the tunica vaginalis, and to prevent the descent of a hernia, and subsequently the hydrocele may be treated in the ordinary way. Should this not suffice, the funicular process may be exposed by open incision, the neck ligatured, and the sac removed. As a rule, however, when the obliteration of the funicular portion has been accomplished, the hydrocele undergoes a spontaneous cure.

Encysted hydrocele of the testicle and epididymis.—This term is applied to a cyst or cysts formed in connection with the testicle or epididymis, but having no communication with the cavity of the tunica vaginalis. Cysts in connection with the testicle itself are very rare. They are formed by the collection of fluid between the tunica albuginea and tunica vaginalis, and require no further description here. Encysted hydroceles of the epididymis, however, though still rare, are more often met with, and may be divided into (1) the *subserous cysts*, which are of no clinical importance, except that they may sometimes become pedunculated, and then getting detached may form loose bodies in the tunica vaginalis, and (2) the *parenchymatous* or *spermatic cysts*. The latter are thin-walled, membranous cysts lined with cubical epithelium, and containing a watery, slightly opalescent or milky fluid, in which there is often an abundance of spermatozoa. The presence of the spermatozoa may be due to the rupture into the cyst of one of the seminal ducts; or to the cyst being developed in connection with a seminal duct. The origin of these cysts is doubtful. They are generally believed, however, to be developed from some of the fœtal remains of the Wolffian body or Müllerian duct, such as the organ of Giraldès, hydatid of Morgagni, etc., so abundant in the situation of the epididymis.

Signs.—They appear as tense, fluctuating, translucent, moveable, globular, smooth or lobulated swellings, without impulse on cough, and situated immediately above or behind the testicle. The cord is generally free. They are often combined with an ordinary hydrocele.

Treatment.—These cysts usually give rise to no inconvenience, but should they increase in size and cause pain, they may be tapped in the ordinary way, or, if this fails, dissected out with strict antiseptic precautions. Injection has not been attended with success.

Encysted hydrocele of the spermatic cord is a collection of serous fluid in an unobliterated portion of the funicular process of the tunica vaginalis. The fluid is similar to that of an ordinary hydrocele. The coverings of the cyst are those of the funicular process, viz., the skin, and the superficial, intercolumnar, cremasteric, and infundibuliform fasciæ; the vas with the spermatic arteries and veins are behind it.

Signs.—An encysted hydrocele of the cord appears as a well-defined, tense, oval or globular, fluctuating, freely moveable swelling in the course of the spermatic cord. It is unconnected with the testicle below, and cannot be reduced into the abdomen above although it may be pushed some distance up the inguinal canal. It is translucent, and gives no impulse on coughing. But when high up in the inguinal canal, it may be difficult to distinguish from a small irreducible hernia, as an impulse is communicated to it from the abdominal walls, and it may be impracticable to detect its translucency. A cautious puncture with an exploring needle may then be necessary to diagnose it.

Treatment.—Painting with tincture of iodine may first be tried. This failing, the cyst should be punctured with a small trocar and cannula. Should it refill, it may be injected with iodine, etc., like an ordinary hydrocele, or it may be laid open by an aseptic incision; or better, dissected out, and if it communicates with the peritoneal cavity, a fact which may be determined by passing an aseptic probe along its neck, the neck should be freed and ligatured as high up as possible. Before undertaking its radical cure by injection, it must be ascertained that there is no communication with the peritoneum. This may usually be done by noting that no decrease in size takes place on applying steady pressure for some little time.

A hydrocele of a hernia sac is said to result when the sac of a pre-existing hernia has become distended with fluid after the contents of the sac have been reduced and its neck has from some cause, as an adherent piece of omentum, become obliterated. *Signs.*—The swelling is elastic, fluctuant and, perhaps, translucent. There is no impulse on coughing, but a history of a former hernia in the situation in which the swelling has formed. *Treatment.*—It should be cut down upon the neck ligatured, and the sac itself dissected down.

Chylocele is a distension of the tunica vaginalis with chylous fluid which when endemic in origin contains filarial embryos. It forms an opaque instead of a translucent tumour.

Varicocele is formed by the pampiniform plexus of veins when more than normally dilated and elongated to become tortuous. It is a congenital variation from the normal in the direction of excess. The pampiniform plexus belongs in the embryo to the Wolffian body, and is later on transferred with the vas deferens to the service of the testis. In the course of development many of the embryonic veins are obliterated, as may be seen if sections be made of the cord at various ages, and this obliteration goes on to a more marked extent on the right side than on the left. After puberty the veins are to be felt in most people on the left side when the scrotum is relaxed. It is an excessive persistence of these veins and their dilatation and elongation as puberty is reached that constitutes varicocele. In a few cases the varicocele is so large as to form without doubt a pathological condition. And in a certain percentage of perfectly healthy men the veins are sufficiently marked to be called a varicocele by medical examiners for the military and other public services. For when other causes of temporary fulness occur, such as hard work, marching, straining, long standing in hot climates, and debility, dragging and aching pains begin to be felt and supply a reason for going off duty or an opportunity for malingering. Hence the reason for requiring the excision of varicocele before entering the services. In some cases, either in the individual or in other members of his family, other venous dilatations, such as piles and varicose saphenous veins are found. Exceptionally a varicocele is symptomatic of an abdominal tumour, such as a kidney tumour, or aneurysm. Other so-called causes, such as the greater length of the left spermatic vein, the fact that it opens at a right angle into the left renal vein, that it is crossed by the sigmoid flexure, that the blood pressure is less in the vena cava than in the left renal vein, may be dismissed by saying that they are anatomical conditions common to all healthy men. Hypochondriasis tends to fix the patient's attention upon these veins. He accuses himself of having caused it by early sexual excitation, which is quite incorrect. He fears it may result in impotence, which it does not. He dreads sterility, for which there is likewise no solid grounds. It is true that extreme cases of varicocele are sometimes connected with a small soft testis which has undergone fatty degeneration. But as this is on one side only,

FIG. 524.—Varicocele. (St. Bartholomew's Hospital Museum.)

the patient has the other testis intact, for it must be phenomenal to meet with fatty degeneration of both.

Pathology.—The varicocele is in most cases on the left side, in about 15 per cent. it is bilateral, the left being mostly the larger; in a very few cases, say less than 1 per cent., there exists a varicocele on the right side only. Two types have been distinguished, large tortuous veins in the cord up to the external ring with a firm testis, and masses of small veins clustered around a small soft testis.

Signs.—A knotted pyriform mass is seen through the thin skin of the soft scrotum. The dilated and tortuous thick-walled veins can be felt to be moved by the contractions of the cremaster muscle, hence the comparison of the feel to worms in a bladder. An expansile thrill is felt in the veins on coughing, they are emptied on pressure when the patient is lying down, and refill when he rises, although the finger is placed on the external ring. But there is no gurgle nor sudden slipping away as in the case of the reduction of hernia. The symptoms are those of a sense of fulness, dragging, or severe aching coming on at the end of a day's work, and relieved by recumbency. The weight of the veins makes the testis hang lower than usual, and so it may be often squeezed between the legs. The testis is usually a little smaller and softer, but seldom much atrophied. The *treatment* may be either palliative or radical.

Palliative treatment consists in cold sponging, the use of shower-baths, healthy exercise, regulation of the bowels, and the administration, when indicated, of ferruginous tonics; whilst the mental anxiety of the patient should be relieved by the assurance that atrophy or impotence need not be feared. *Locally*, a suspensory bandage should be worn, or the veins braced up by drawing the lower part of the scrotum through a *Wormald's ring.*

Radical treatment should be undertaken (1) when the varicocele is large or causes much pain; (2) when it acts as a bar to entering the public services; or (3) when it appears to be inducing atrophy of the testicle. Whether it should or should not be undertaken for the cure of mental distress, must be left to the judgment of the surgeon in each individual case. (*a*) *Open method.*—The open method should be always chosen, the pubic hair is shaved, and the incision is made over the external ring rather than in the scrotum, since it is difficult to thoroughly disinfect the skin in the latter situation, and the most rigid antiseptic precautions must be taken, for fatal cases of septicæmia have originated from germs in the scrotal folds. The vas having been pressed back, the veins are made prominent by nipping them up with the finger and thumb. The incision, which should be one inch in length, is then made through the skin, and continued in depth till the veins are fully exposed. An aneurysm-needle armed with kangaroo tendon or fine silk is then passed beneath the pampiniform plexus of veins, care

being taken not to include the deferential veins, lest the testicle slough. The veins forming the plexus, including the spermatic artery, are now tied by transfixion at the external ring, a clamp forceps applied a little below, and the veins divided. The pampiniform plexus is next drawn up into the wound, isolated as far as the testicle, a ligature applied below, and the whole varicocele cut away. The ligatures on the ends of the cut veins are now tied together, alternatively, the stumps are thus sutured together, so shortening the cord and bracing up the testicle. The wound is accurately closed by fine sutures, and an antiseptic dressing applied. (*b*) *Subcutaneous method.*—It is only fit for slight cases, and may not be accepted by the medical examiner for the services. The vas, which can always be felt as a rounded cord, is separated from the veins; with a nævus-needle a thread of fine silk is passed between the veins and the vas, and then back again between the veins and the skin, and the veins tied, allowing the knot to slip through the puncture in the skin. The procedure is repeated three-quarters of an inch above, and the scrotum placed in an antiseptic dressing. A hard mass remains for some months between the situations of the ligatures, but gradually disappears in time.

Lymphocele is a dilated and varicose condition of the lymphatics of the cord. It is very rare. The signs are like those of varicocele. The dilated lymphatics should be dissected out.

Tumours of the spermatic cord are occasionally met with; lipomata only are here described. *Lipomata* are not very uncommon. They occur as elongated, soft, semi-fluctuant, smooth, or occasionally finely lobulated swellings. They spring from the subperitoneal fat, and during their descent along the inguinal canal may draw down a process of peritoneum, into which a hernia may descend. They are more often met with on the left side, occur in lean as well as in fat people, and increase slowly and steadily in size. They may be distinguished from an inguinal hernia, with which they are often associated, by being irreducible, by having as a rule no impulse on cough, by their elastic feel, and by descending lower when traction is made on the testicle. *Treatment.*—Open incision and dissecting out the growth.

Torsion of the spermatic cord.—A twisting of the cord is only possible when the testis hangs in the tunica vaginalis by a mesorchium. The epididymis is felt in front instead of behind the body of the testis. It may occur either in a testis to all external appearance previously normal, or in a testis retained in the inguinal canal. The twisting has been attributed to spasm of the cremaster. If unrelieved the testicle will atrophy or necrose.

The symptoms generally come on suddenly after great strain or exertion. There is a tender and painful swelling in the groin or scrotum, dull to percussion, irreducible, without impulse on cough, and attended by some fever. Vomiting is nearly always present,

and there may be constipation. Thus when the testis is retained a strangulated hernia is very closely simulated.

Treatment.—When seen early the cord may be untwisted if the testis is in the scrotum, the symptoms at once disappearing as in Nash's case. If the testis is in the groin or inguinal canal, it should be removed, and the canal and ring closed by sutures.

Hæmatocele is an effusion of blood into the cavity of the tunica vaginalis. Blood may also be effused into an encysted hydrocele of the testis, epididymis or cord, into the substance of the testicle itself, or into the tissue of the scrotum; and to such the terms hæmatocele of the testis, hæmatocele of the cord, etc., have been applied. All of these conditions, however, are too rare to need description here.

Causes.—An ordinary hæmatocele may be due to a blow on the testicle, or a strain in lifting heavy weights, or a like injury to a hydrocele; to puncture of the testicle or a blood-vessel in tapping a hydrocele; or to the giving way of a weakened or varicose vessel in consequence of the alteration in tension on removal of the hydrocele-fluid by tapping. At times, however, it may occur spontaneously, and is then probably due to some atheromatous or other change in the vessels, or chronic inflammation of the tunica vaginalis.

Fig. 525.—Hæmatocele. (St. Bartholomew's Hospital Museum.)

Pathology.—The effused blood may be absorbed, or it may clot and be deposited on the walls of the sac, giving the hæmatocele on section the appearance of an aneurysm (Fig. 525); or the central portions of the clot may break down into a chocolate-coloured fluid, which under the microscope is seen to consist of disintegrating blood corpuscles and hæmatin and cholesterin crystals. At times suppuration may take place, the fluid in the sac then consisting of a mixture of broken-down blood and pus. Calcification of the walls in old-standing cases may occur.

Signs and diagnosis.—Hæmatocele comes on suddenly, appearing as a smooth, tense or semi-fluctuating, oval or globular, non-translucent swelling in the scrotum. At first there may be considerable pain in the testicle and ecchymosis of the scrotum; but later, neither, as a rule, will be present. Testicular sensation is generally discovered behind the swelling. The freedom of the cord and absence of impulse on coughing should at once serve to diagnose it from a hernia, and its non-translucency from a hydrocele. But from malignant or other growths it is often difficult to distinguish it; and, indeed, in some cases it is only after puncture with a

grooved needle or even after an exploratory incision, that this can be done. The history of its sudden onset, its shape, the absence of the varying consistency noted in malignant disease, the non-involvement of the lumbar glands or of the cord, and the presence of testicular sensation posteriorly, should help in the diagnosis. On puncture a chocolate-coloured fluid escapes in the one case; arterial blood, or nothing at all, in the other.

Treatment.—When the hæmatocele is recent, rest in bed, the application of cold or of evaporating lotions, and the elevation of the part on a pillow, may lead to the absorption of the blood. If this fails, the blood may be withdrawn with a trocar and cannula. When such is done, however, the sac in our experience generally refills, and we believe time is gained in the end by at once making a free incision into the sac, turning out the clots, dissecting away the walls of the sac and closing the wound by suture. Care should be taken not to injure the testis or cord. In long-standing cases, and especially when the walls are much thickened, this treatment is clearly indicated, but if, on laying the sac open, the walls are found of cartilaginous consistency, perhaps calcified, and the patient is old or broken down in constitution, excision of the testicle is then called for, as otherwise long-continued suppuration, which may terminate in exhaustion and death, may ensue. Where suppuration has occurred, a free incision should, under any circumstances, at once be made.

Acute inflammation of the testicle is known as *orchitis* or as *epididymitis*, according as the body or the epididymis is primarily or chiefly affected.

Causes.—Gonorrhœa is the most frequent cause; but injury of the testicle, and irritation of the prostatic urethra, as from the tying-in of a catheter, or from the impaction of a calculus or fragment of a calculus, are not uncommon causes. Orchitis sometimes occurs during an attack of mumps, also it may follow typhoid fever, and is then said to be due to metastasis. It also occurs in gout, occasionally in rheumatism and malaria. It has also been attributed to the use of strong injections for the cure of gonorrhœa. How inflammation of the testicle is induced by the irritation of the urethra is a disputed question. It is variously taught, however, that it is due to—1, inflammation spreading along the vas, the most likely view; 2, reflex irritation; and 3, metastasis.

Pathology.—The walls of the tubules and the intertubular connective tissue become infiltrated with inflammatory products, and the tubules filled with desquamated epithelium. Resolution usually occurs, leaving the testicle little or not at all impaired either in structure or function. Suppuration, however, is occasionally induced; and when the epididymis is chiefly involved, the inflammatory material, in place of being absorbed, may be converted into fibrous tissue, which, subsequently contracting, may cause obstruction of the tubules of the epididymis. Such may be known to

have occurred by the presence of a small hard lump in the region of the globus minor or major (*fibroid thickening of the epididymis*). An effusion of fluid into the tunica vaginalis (*acute hydrocele*) is very common, but more so in epididymitis than in orchitis, because the visceral layer of the tunica vaginalis is in contact with the inflamed tissue in the former case, but is separated from it by the thick tunica albuginea in the latter.

Signs. — In a well-marked case there is intense pain in the testicle, with a dragging or aching pain in the groin and along the course of the cord. The testicle is swollen and exquisitely tender on handling; the vas feels uniformly swollen and thickened; and the skin of the scrotum is œdematous and of a dusky-red colour. When the stress of the inflammation falls on the epididymis, the pain and swelling is chiefly confined to the lower and back part of the testicle —the region of the tail of the epididymis, *i.e.*, the globus minor— and fluid will often be detected in the tunica vaginalis. The discharge, if the inflammation of the epididymis occurs during an attack of gonorrhœa, generally ceases or becomes less when the inflammation is at its height. A slight urethral discharge has followed orchitis in which all connection with gonorrhœa could be excluded. The local signs are often accompanied by sharp febrile disturbance, raised temperature, furred tongue, nausea or even vomiting, and constipation.

Treatment.—When the attack is acute, rest in bed with the testicle supported on a pillow is desirable. Fomentations, and, in the intervals, hot boracic poultices applied to the testicle and groin give the most relief. Internally a brisk purge should be given at the outset, followed by saline laxatives and small doses of antimony. If the pain is very severe, opium or salicylate of soda (grs. xx. every hour or two) may be given; or belladonna and glycerine may be applied; or a vein of the scrotum opened; or the tunica vaginalis or testicle punctured to relieve tension either with a needle in several places or with a tenotomy knife. If suppuration occurs, a free incision should be made to let out the pus. In subacute attacks, where the patient is unable to leave his work, a suspensory bandage should be worn. If the testicle remains enlarged it should be strapped. Appropriate remedies must be given should the inflammation have a gouty, rheumatic, or malarious origin.

Chronic inflammation of the testicle may be a sequel to the acute disease; or it may begin as a subacute affection, and, like the acute form, may involve either the body of the testicle or the epididymis, or both. The two chief causes of chronic inflammation are syphilis and tubercle; but it may occur independently of either of these affections, and should then, for the sake of distinction, be called *simple chronic orchitis* or *epididymitis*. The *syphilitic* and *tuberculous* forms are described separately under those heads.

Signs.—The testicle appears enlarged, smooth, laterally-compressed, egg-shaped, hard, heavy, and painful on pressure; the testicular sensation is not lost; the vas is but slightly thickened; the skin is non-adherent, and the epididymis (except when the disease is limited to that part) is not distinguishable from the body of the organ. In *chronic epididymitis* an indurated, painful and tender lump is felt in the situation of the globus minor or major.

Treatment.—Mercury or iodide of potassium should be given internally, and strapping applied to the enlarged organ when the body is chiefly affected. In chronic epididymitis, in addition to

Fig. 526.—Tubercle of the testicle with local hydrocele. T. Body of testicle. E. Epididymis greatly enlarged. V. Vas much thickened. (St. Bartholomew's Hospital Museum.)

internal remedies, inunction with mercurial ointment may be of service.

Tuberculous disease of the testis may result from (1) primary infection, *i.e.*, the tubercle bacillus, having entered the blood-stream from without, may find its locus minoris resistentiæ in the testicle, as the result, perhaps, of some slight injury or gonorrhœal infection; or (2) it may be secondary to similar disease existing in neighbouring organs, such as the bladder, prostate, etc., and is then due to extension of the disease along the vas deferens.

Pathology.—The disease generally begins in the epididymis, and thence may spread to the body of the organ. It may also, when it primarily attacks the testis, extend along the vas to the vesicula

seminalis and prostate, and thence to the bladder, and even to the ureters and kidneys. In some cases the testicle appears to be the starting-point of a general tuberculosis; in others, merely to be involved in common with other organs in the general disease. In many instances, however, the disease may remain localised to the testicle, and no other manifestation of tubercle occur in the body. The inflammatory products infiltrating the epididymis and testicle have a great tendency to undergo caseation, forming the non-vascular yellow masses of cheesy-looking material so characteristic of the disease (Fig. 527).

Signs.—The disease usually begins insidiously and with little pain. The epididymis, especially the head or the tail if the tubercle spreads from the bladder or prostate up the vas, and later the body of the testicle, are found enlarged. The testicle is usually but slightly tender on handling, and the testicular sensation is not lost; a hydrocele (Fig. 526) may be present, or part of the tunica vaginalis may be obliterated. Subsequently the vas becomes irregularly thickened, so that it feels like a string of beads, and the skin adherent, especially behind and below where it is in contact with the epididymis without the intervention of the tunica vaginalis (Fig. 526); whilst still later the skin may give way and a fungus composed of the infiltrated tubules protrude, or a discharging sinus be produced. The vesicula seminalis or prostate may now be felt enlarged on examining by the rectum, and bladder or urinary troubles may set in; whilst symptoms of tubercle in the lung, larynx or other organs may supervene and the patient succumb to tuberculous disease. At other times no constitutional signs manifest themselves, and the patient may completely recover.

Fig. 527.—Tubercle of the testicle. (St. Bartholomew's Hospital Museum.)

Diagnosis.—From *syphilitic orchitis* it may generally be distinguished by the enlargement of the epididymis, the moniliform thickening of the vas, presence of testicular sensation, adhesion of the skin, tendency to softening and suppuration, enlargement of the vesicula seminalis, concomitant signs of tubercle elsewhere, non-effect of anti-syphylitic remedies and the discovery of tubercle bacilli, should there be an open wound, by cultivation experiments of the discharge. From *malignant* disease it may, as a rule, be readily diagnosed, in that the malignant affection is of rapid growth, and affects the whole organ without distinction of body or epididymis.

Treatment.—In the early stages, before the vas or vesicula

seminalis has become involved, some surgeons advise the removal of the organ for the purpose of preventing, if possible, general dissemination of the disease, and where both testicles are affected, even the removal of both. Others, however, rely on constitutional treatment, and only advise the removal of the testicle should it become destroyed by the disease. If the vesicula seminalis is found affected in the early stages, or signs of tubercle are discovered in other parts, the testicle should on no account be excised. Where the disease is apparently confined to the epididymis, the latter structure may be dissected off the testis, or an incision may be made into it, and the caseating tubercle scraped away. By thus merely removing the epididymis the patient is not rendered impotent, which is important in bilateral disease. The *constitutional treatment* is that already described under *Tubercle* (p. 93). The *local treatment* consists in suspension of the organ, avoidance of horse or other violent exercise, and recumbency during an exacerbation of the inflammation. Should the tubercle soften or suppuration occur, the abscess must be opened, thoroughly scraped with a Volkmann's spoon, and the wound plugged with iodoform gauze. If intractable sinuses remain, they should be also scraped. If a fungus forms it will frequently recede under rest in bed, cleanliness, and the application of a stimulating ointment or of iodoform. Should the testicle become completely disorganised it had better be excised. (See *Excision of the Testis*, p. 1060.)

FIG. 528.—Syphilitic testicle. Gummatous variety. (St. Bartholomew's Hospital Museum.)

Syphilitic disease of the testicle occurs during the late secondary and the tertiary stages of syphilis.

Pathology.—The lesion in the secondary stages of syphilis usually takes the form of a small-cell-infiltration of the intertubular connective tissue (*syphilitic interstitial orchitis*); in the later stages, of distinct gummatous masses, resembling gummata in other situations (*gummatous orchitis*). The body of the testicle alone is usually affected, and though, in some instances, *syphilitic epididymitis* is met with, the cord and epididymis generally escape. In the secondary stage both testicles may be implicated, either simultaneously, or, as more often happens, one after the other, the disease here, as in other secondary affections, manifesting its tendency to be symmetrical. Under appropriate treatment the small-cell-infiltration may be completely absorbed, leaving the testicle apparently little, if at all, affected; or it may undergo fibroid changes, and the subsequent shrinking of the fibrous tissue produce more or less atrophy of the

organ. But it seldom breaks down and suppurates as the gummatous form in patients with undermined constitutions is apt to do. In the tertiary affection one testicle only is, as a rule, involved, the asymmetrical character of tertiary syphilis being thus borne out. The gummatous masses may clear up under treatment, but where the constitution is impaired they are liable to break down and suppurate, or a fungous protrusion, though rarely, may occur. The typical appearance of a gummatous testicle on section is seen in Fig. 528, and microscopically in Fig. 21, p. 75. The organ is

Fig. 529.—Syphilitic testicle. T. Gumma in body of testicle. E. Epididymis not enlarged but with a small cyst in the globus major. H. Large vaginal hydrocele. (St. Bartholomew's Hospital Museum.)

occupied by large yellowish-white nodules of a tough, fibrous, non-vascular material; some of the gummata are distinct; the remainder have coalesced into a mass which occupies the anterior part of the organ. A loose fibroid tissue, which is very vascular and of a pink colour in the original specimen, surrounds and separates the nodules.

Signs.—Syphilitic disease is insidious and painless in its onset, the testicle often attaining some size before the patient's attention is directed to it. The testicle is enlarged, very hard, not tender on handling, and, as a rule, absolutely painless; the testicular sensation is completely lost; the skin is not involved, but appears natural, and is freely moveable over the swelling. The signs, however, vary

somewhat according to the stage of syphilis at which the testicle is affected. Thus, in the secondary stages, the testicle is smooth, oval, and often laterally compressed; in the tertiary, nodular and irregular, and the tunica vaginalis frequently contains fluid (*vaginal hydrocele*) (Fig. 529). In the secondary, usually both testicles are affected; in the tertiary, often only one. In the tertiary, moreover, the gummata, in neglected cases, or where the constitution is undermined, may break down, the skin become involved in the inflammation and give way, and a sore having the characters of a tertiary syphilitic ulcer result. More rarely a fungus may protrude. The characters of the secondary and tertiary disease, however, often merge into one another.

Diagnosis.—A syphilitic testicle may have to be diagnosed from *simple orchitis* and from *tuberculous disease*. The freedom of the vas and epididymis, the absence of all pain and tenderness on

Fig. 530.—A chondroma, so-called, of the testicle.
(St. Bartholomew's Hospital Museum.)

handling, the loss of testicular sensation, the hardness of the organ, the non-implication of the skin, the presence of a vaginal hydrocele, the history of syphilis, the fact that the patient has not had gonorrhœa or a previous attack of acute orchitis, nor received an injury to the testicle, and the absence of signs of tubercle in other organs, point to the disease being of a syphilitic origin. The presence of a vaginal hydrocele is not of much diagnostic value, since it is almost as common in tubercle as in syphilis. It must not be forgotten, however, that syphilis may occur in a tuberculous subject; and that the characters of the two affections may then be more or less combined.

Treatment.—The earlier the testicle is affected in the course of constitutional syphilis, the more marked will be the effect of mercury; the later, of iodide of potassium. Often the best results are obtained from the two drugs combined. Locally, the testicle may be merely suspended; or it may be strapped in the earlier stages with advantage. Any fluid in the tunica vaginalis will

commonly be absorbed during the treatment, though sometimes tapping may be required. Should the skin give way, and an ulcer be produced, it should be treated like other syphilitic ulcers. Sometimes neither iodide of potassium alone nor in combination with mercury has any effect; in such cases, and in those rare instances in which the testicle becomes totally disorganised, extirpation may become necessary.

Chondromata or cartilaginous tumours of the testicle are very rare. An example, however, is shown in the accompanying illustration (Fig. 530). They may be known by their extreme hardness. They were thought to arise in connection with portions of the embryonic cells of the protovertebræ carried down from the lumbar region with the testicle during its descent. Now with more reason they may be considered to be endotheliomas (see p. 133). Removal of the testicle is the proper treatment.

Cystic disease of the testicle embraces two distinct conditions, (*a*) one a simple, benign, cystic transformation of the testis, the *cysto-fibroma* or *simple cystoma*, and (*b*) a rapidly-growing malignant tumour (the so-called *cysto-sarcoma*) in which besides its cystic nature there are sarcomatous elements. Both are probably varieties of the same disease, and differ chiefly in the structure of the inter-cystic stroma, which, in the simple cystoma, consists of simple fibrous elements, and in the malignant form of an embryonic connective tissue. They run widely different clinical courses, the one being benign, and not tending, as a rule, to recurrence after removal; the other growing rapidly and leading to dissemination in distant organs as well as recurrence *in situ* after removal.

Signs.—The *simple cystoma* grows slowly, and seldom attains a size larger than a turkey's egg. It is smooth on the surface, and is ovoid in shape. In consistence it varies according to the size of the cysts. The spermatic cord is not involved, and the lumbar glands are not enlarged. The disease usually occurs in middle life. The *cysto-sarcoma* grows rapidly, and in the space of a few months may attain the size of a cocoa-nut. The surface is usually uneven and the oval shape of the testis is speedily lost. The cysts, which are large and numerous, impart a sense of elasticity to the touch. The lumbar glands may be enlarged if the disease has existed long enough.

Treatment.—In both varieties the testicle should be removed as soon as the growth is recognised. Recurrence is very likely to take place in the malignant type, and sometimes even in the benign variety, but when this happens the intercystic connective tissue is usually found to be on the borderland of malignancy.

Other benign tumours of the testicle, such as fibroma, myxoma, myoma, and osteoma occur, but they are too rare to need description here.

Malignant disease of the testicle occurs in the form of round-celled *sarcoma*, more rarely in the form of soft *carcinoma*;

but, without a microscopical examination, the two diseases, even on section, are often quite indistinguishable. *Sarcoma* begins in the intertubular connective tissue, and most frequently occurs in early life; *carcinoma* in the tubules, as a proliferation of the epithelial lining, and is most often met with after the period of middle age. In both, the body of the organ is primarily affected and all distinction between it and the epididymis is soon lost. Some effusion into the tunica vaginalis may at first occur; the two surfaces, however, rapidly become adherent, the skin is implicated, and a fungating mass protrudes externally. The lumbar glands are generally affected, the inguinal only becoming involved after the skin has been reached. Later general dissemination through internal organs occurs. In a typical case (Fig. 531) the growth appears, on section, like a mass of vascular brain-matter, blotched in places with blood; whilst fibrous bands, the remains of the trabeculæ testis, are generally seen traversing the growth. Masses of cartilage are often found in the sarcomata, and cysts, sometimes containing intracystic growths, are not uncommon (*cystic sarcoma*). The disease formerly described as cystic sarcocele would generally appear to be of such a nature.

Fig. 531.—Soft carcinoma of the testicle. (St. Bartholomew's Hospital Museum.)

Signs.—The swelling is at first generally uniform, smooth, and elastic, or tense and hard, and no distinction between the body and the epididymis can be made out; but later the cord becomes thickened and the lumbar glands enlarged, and the tumour may feel hard in one place and soft in another. Ultimately the skin becomes adherent, gives way, and a fungating mass, covered with a sanious discharge, protrudes.

Diagnosis.—A progressive solid enlargement without inflammation which iodide of potassium and mercury, with strapping, fail to arrest, requires to be explored with a view to removal. It is generally too late for success when lancinating pain, implication of the skin and lumbar glands, enlargement of the scrotal veins, protrusion of a bleeding fungus, and the constitutional cachexia, obviously indicate malignancy. In the early stages, however, a puncture or even an exploratory incision may be necessary to distinguish it from chronic orchitis, hæmatocele, and syphilitic orchitis. Thus, in malignant disease, arterial blood will generally flow; in hæmatocele, a chocolate-coloured fluid containing hæmatin crystals and broken-down blood corpuscles will escape; and in chronic orchitis, whether simple, syphilitic, or tuberculous, nothing beyond perhaps a drop or two of blood will be withdrawn by the cannula. At times a piece of the

growth may come away in the end of the cannula, and a microscopical examination of this will further aid in the diagnosis.

Treatment.—Unless the glands are much affected, the cord is thickened, and great emaciation or cachexia is present, with signs of the disease in the internal organs, excision of the testicle should be performed. When this appears undesirable from the above-mentioned reasons, all that can be done is to give opium to relieve pain and tonics to keep up the general health, and to apply some disinfecting lotion to remove the fœtor attending the fungating mass. After removal of the testicle an early recurrence of the disease in the lumbar lymphatic glands or in the internal organs is only too probable.

Excision of the testicle.—The parts having been shaved, make an incision over the growth from the external abdominal ring to the bottom of the scrotum. Free the cord when healthy from its connections as high as the internal abdominal ring, and having transfixed and tied it with a stout ligature, divide it below the ligature. Taking hold of the distal end of the cord, enucleate the testicle with a few touches of the knife, being careful not to cut through the scrotal septum, and so remove the other testicle at the same time, a danger best avoided by giving the sound testicle into the charge of an assistant. Some surgeons instead of applying a single ligature to the cord clamp it, and after the testicle is removed tie the vessels separately. When this is done, however, there is some danger of the cord slipping from the grasp of the clamp into the inguinal canal. Troublesome hæmorrhage may then occur. Moreover, some vessel may escape being tied, and recurrent bleeding take place when the patient gets warm in bed.

If the upper part of the vas is infiltrated as in tubercle, it is carefully separated from the spermatic artery where the two join, and having tied the artery, the vas is gently drawn on until it comes away from the vesicula, or it may be followed down to the vesicula by enlarging the incision and pushing back the peritoneum.

Atrophy of the testicle may be simply the result of old age; or it may be due to—1, inflammation, especially that occurring during an attack of mumps; 2, interference with its blood supply as from the compression of the spermatic artery by a new growth or aneurysm; 3, obstruction to the venous return as in varicocele; 4, direct pressure on the organ, as by an old hæmatocele, or by the abdominal muscles or by a truss when the testicle is retained in the inguinal canal.

Neuralgia of the testicle is occasionally met with, but pain in the testicle should not be pronounced neuralgic till the various diseases of the kidney, rectum, bladder and prostate, which may give rise to reflected pain in the testicle, have been excluded. When no cause for the pain can be discovered, the ordinary neuralgic remedies should be given, although the prospect of success from their use is not great.

Retained testicle.—Non-descent of the testicle is said to be due to—1, the formation of adhesions in any part of its course into the scrotum; 2, disproportion between the size of the testicle and the abdominal rings; 3, paralysis of the gubernaculum testis; 4, too short a condition of the spermatic cord; and 5, malformation of the testicle. Thus the union between the vas deferens and the testicle, *i.e.*, the union of the Wolffian duct and the portion of blastema from which the body of the testicle is developed, may not occur, and the vas descend alone. The testicle may be arrested anywhere along its normal line of descent (*retained testis proper*), or it may depart from its normal route and be found located elsewhere than in its proper situation in the scrotum (*ectopia testis*). Of *retained testis proper* there are four chief varieties, viz., 1, abdominal retention in which the testis is located at or near its starting point in the lumbar region; 2, iliac retention in which it has become arrested in the iliac fossa; 3, inguinal retention in which it lies in relation to the inguinal canal, and of which there are three sub-varieties; (*a*) *internal inguinal*, when the testis is located at the internal abdominal ring, (*b*) *interstitial inguinal*, when it lies in the canal itself, and (*c*) *external inguinal*, when its position is at the external abdominal ring; 4, cruro-scrotal retention, where the organ occupies the fold between the scrotum and the thigh. In these situations it is often associated with a congenital hernia. Of *ectopia testis*, there are two varieties, (*a*) *perineal ectopia*, in which the testicle is situated in the perineum immediately in front of the anus, and (*b*) *crural ectopia*, in which the testicle leaves the abdominal cavity by the crural canal, and appears in the thigh just below Poupart's ligament.

Treatment.—In *abdominal* and *iliac retention* nothing can be done. In *external inguinal retention* the testicle should be coaxed into the scrotum by gentle and oft-repeated manipulations, and a truss with a <-shaped pad, the arms of the < embracing the testis, applied over the inguinal canal should there be signs of a hernia. If this truss does not keep up the hernia the testis had better be removed and the canal and ring completely closed by suture. In some instances the cord may be elongated sufficiently to allow the testis to be placed in the scrotum by detaching the globus minor from the body of the organ, and thus turning the testis upside down. The sac of the hernia may then be removed and the canal and ring sutured (p. 919). When the testicle is retained in the inguinal canal (*interstitial retention*), time should be given it to descend, and a truss applied, if possible, over the internal ring. Should it not descend as the child grows older, the question of its removal must be raised, as in this situation atrophy of the organ is nearly sure to ensue, and it is liable to be attacked by inflammation, and has become affected by malignant disease. Moreover, it exposes the patient to the risks of hernia. Some recommend that the testicle be returned into the abdomen, especially when the condition is bilateral, but this is not advisable,

since, should an attack of gonorrhœal epididymitis be contracted, the inflammation might spread to the general peritoneal cavity, and should malignant disease occur, the testicle could not so easily be removed. In ectopia testis an attempt may be made to place the testis in the scrotum by a plastic operation, or, if this is impracticable, the testis should be removed.

The testis may be fixed in a pocket of the scrotum, and for a few days the scrotum fixed to the skin of the thigh. Or the testis is passed through a half-inch incision at the bottom of the scrotum where it is allowed to remain for a week; it is then put back into the scrotum, and the wound in the skin sewn up.

Removal of glands in the groin (see p. 445).

Surgical Diseases of the Female Genital Organs.

Examination of the female genital organs.—*Position.*—The patient may be placed—1, in the *obstetrical position*, *i.e.*, on the left side, with the left arm drawn back, the buttocks close to the edge of the couch and the thighs well flexed; 2, in the *dorsal position*, with the buttocks raised on a pillow to take off intestinal pressure, the knees apart, and the feet supported; or, 3, in the *genupectoral position*, *i.e.*, resting on the knees and chest with the head turned to one side; the pressure of the intestines is thus removed, so that the bladder, vagina, or rectum, when a speculum is passed, is distended by atmospheric pressure.

The vagina is examined by covering the finger with vaseline, sliding it over the posterior fourchette and up the posterior wall so as to avoid touching the clitoris. The uterus, ovaries, and pelvis generally, are examined bimanually, *i.e.*, with one finger in the vagina and the other hand on the hypogastrium.

A vaginal speculum is warmed and greased, then the labia are separated by the left thumb and forefinger, the posterior fourchette is pressed backwards and the speculum pushed up the posterior wall until by slight movements the cervix appears. It can be illuminated by a small electric lamp or head mirror. A uterine sound is graduated, and has a blunt point and a bend of 160 degrees, about two and a half inches from the tip, *i.e.*, the normal length of the uterine cavity. After being sterilised it may be passed, guided by the finger, or through the speculum, after fixing the cervix by seizing the posterior lip with a volsella.

A rectal examination should be substituted for a vaginal one in unmarried women. It is a valuable supplement to the vaginal, especially when made under an anæsthetic, and when the uterus is drawn down and fixed by grasping the cervix with a volsella, as then the finger can reach up behind the uterus and examine the ovaries, tubes, and broad ligaments.

Diseases of the Vulva.

Vulvitis, or inflammation of the vulva, is in adults most usually the result of gonorrhœa, but occurs in young children, from other causes, such as cold, injury, the irritation of thread-worms, etc. Sometimes the sebaceous glands and hair-follicles of the labia are chiefly affected, the parts then appearing dotted over with small red pimples, and later, if suppuration occurs, with small pustules. There is usually much redness and œdema, and an offensive discharge. It is of some importance to recognise the fact that the disease may occur in children from simple causes, as well as from gonorrhœa. The presence or absence of the gonococcus in the discharge will settle the diagnosis. Gonorrhœal complications may follow. *Treatment.*—In addition to the removal of the cause, cleanliness, rest, attention to the general health, and the use of a mild astringent lotion, are all that is usually required.

Abscess occasionally follows inflammation of the vulva. It is often due to the extension of inflammation (generally gonorrhœal) to Bartholin's gland, or to suppuration in a labial cyst. A free and early incision should be made to prevent burrowing of pus, which is otherwise apt to occur, leading to the formation of obstinate fistulæ. Should these form they should be laid freely open.

Adhesion of the labia majora sometimes occurs as an inflammatory affection, the result of vulvitis. The labia should be separated by forcibly drawing them asunder, with the assistance, if necessary, of a probe, and a piece of iodoform gauze placed between them to prevent re-adhesion. If neglected, it may be a source of inconvenience at puberty. The parts are then more firmly adherent, and may require division by the knife.

Varicocele of the labium.—If the veins become very large there is danger of rupture with bleeding externally or the formation of a hæmatoma. The condition is made worse during pregnancy. A small mass may be destroyed by the cautery. When large the base should be transfixed by one or two steel skewers and surrounded behind the skewers by an elastic band. The mass is then cut away and the vessels tied before relaxing the band.

Hæmatoma of the labium may be caused by an injury such as a kick or from falling astride. When a varicocele is present, the violence may be of the slightest. The labium is distended by a blood-clot, and a wall of fibrous tissue forms, which increases in thickness by chronic inflammation. The cavity should be incised, the blood-clot turned out, the bleeding points tied, and the cavity filled with gauze. If the wall is very thick it must be completely excised, and this should be done before suppuration supervenes.

Noma is an infective inflammation of the vulva, attended by phagedænic ulceration, and is not infrequently met with in the

ill-fed, weakly children of the poor, especially after the exanthemata. Like cancrum oris, it probably depends upon the presence of a specific micro-organism. It begins as a dusky-red, indurated patch on one labium, with much swelling and œdema, and spreads rapidly, the central parts often becoming gangrenous. It is attended with severe constitutional disturbance, which soon assumes the typhoid type, and death from exhaustion or septicæmia frequently ensues. It may be followed by much cicatricial contraction, and even occlusion of the vulval orifice. The *treatment* should be energetic. The affected part should be scraped with a Volkmann's spoon, or destroyed by fuming nitric acid or the cautery, and an antiseptic dressing applied; whilst fluid nourishment, stimulants, and iron should be freely given, and opium cautiously administered in doses suitable to the age of the child. In milder cases the application of boro-glyceride may suffice. In very severe cases, the continuous warm bath has been found of great service.

Labial hernia (see p. 913).

Hydrocele of the canal of Nuck.—The processus vaginalis in the inguinal canal or labium remains unobliterated and the hydrocele is then reducible, or it is encysted and forms a small swelling. *Treatment.*—Excision.

Cysts in the labium are generally due to the obstruction of a mucous follicle or the duct of Bartholin's gland as the result of irritation. Dermoid and sebaceous cysts are more rarely met with. The mucous cysts generally contain a glairy fluid, and as their walls are thin, appear as semi-translucent, oval, elastic swellings. They occasionally suppurate. If possible, the cyst should be completely excised; if not, the excision of a portion of the wall, with cauterisation, plugging, or scraping away the lining membrane to ensure healing from the bottom, is employed.

Condylomata and venereal warts are very common in this situation. They require no special description, and should be treated as described under *Venereal Diseases*.

Tuberculous ulceration, Lupus, or Esthiomene (eating), whilst very rare, occurs as a progressive ulceration which has to be distinguished from tertiary syphilis.

Pruritus may depend on various causes, as diabetes, eczema, ascarides, pediculi, etc. These should be sought, and, if possible, removed, the irritation being allayed in the meantime by such remedies as are mentioned under *Pruritus ani* (p. 936).

Elephantiasis of the labium is a tropical disease, the result of filaria. A pendulous tumour increases in size until it prevents walking. The base is transfixed with skewers and surrounded by an elastic ligature, after which the tumour can be easily cut away.

Ruptured perineum (see p. 561).

Tumours.—*Fibrous tumours* are occasionally met with in the

labium. They are usually of the soft variety, and often contain myxomatous elements. They are frequently allowed to attain a large size. Removal is the only treatment. *Fatty tumours* and *nævi* are also met with ; *sarcomata* but rarely.

Epithelioma is not uncommon, and may generally be distinguished from venereal warts and syphilitic, tuberculous, or lupoid ulceration by the surrounding induration, the sinuous and everted edges of the ulcer, the history of the case, the age of the patient, and the early enlargement of the inguinal glands. It is often preceded by chronic eczema and psoriasis or leukokeratosis similar to that described on the tongue. Early and wide removal of the growth, together with any inguinal glands that may be felt enlarged, holds out the only prospect of success ; but when the growth has attained any size, a rapid recurrence is but too frequent. Chronic patches of eczema or psoriasis should be excised before epithelioma occurs.

Diseases of the Female Urethra.

Urethral caruncles or vascular tumours occur as small florid, intensely sensitive excrescences usually situated about the entrance of the urethra, often surrounding it like a ring and perhaps extending some distance up it. They sometimes appear to be due to slight injury during catheterisation, or to inflammation. They give rise to increased frequency of micturition, pain during the act, and intermittent attacks of hæmorrhage, thus somewhat simulating the symptoms of a calculus ; but inspection at once reveals the nature of the affection. *Treatment.*—Ligature, or the application of the thermo-cautery, generally suffices for their cure, but the urethra must not be injured or a stricture will result.

Chronic urethritis, with urethral abscess and sinus.—This is generally caused by gonorrhœa, and is the common latent source of gonorrhœal infection. Vaginal douches prove useless. When the finger is drawn outwards along the urethra pus is pressed out of pockets. Sometimes Skene's tubes, the supposed terminal ends of the Wolffian duct, are affected. A speculum is passed into the urethra to put it on the stretch, and a probe is inserted into the pockets. Each pocket is then wiped out with a strong antiseptic or scraped, or the mucous membrane slit up so as to lay the sinus open.

Catheterisation of the female urethra may be done by a soft rubber or glass catheter. It may be passed in the lateral position with the knees well bent or in the dorsal position with the thighs slightly abducted. It is best to have the meatus plainly in view by separating the labia with the thumb and finger, and putting the end of the catheter straight into the meatus, guided by a good light.

Dilatation of the female urethra for the purpose of examining

the bladder, removing a stone or foreign body from the bladder, or catheterising the ureters is readily effected by the finger, urethral dilator, or graduated sound. The dilatation should be gradual, so as to stretch and not rupture the compressor urethræ lest incontinence follow. Cocain (20 per cent.) on a pledget of cotton-wool, or general anæsthesia, may be employed.

Epithelioma may grow from the urethra or extend to it from the clitoris, forming a papillated mass or a deep indurated ulcer. At first there is a tendency to retention, later to incontinence, of urine. Excision should be done early. If extensive enough to involve the whole urethra and invade the bladder, a suprapubic fistula may be established and the excision wound closed.

Patent urethra.—This may be a congenital condition or the result of excessive dilatation. The careful application of the galvano-cautery will reduce the opening. If this fails the urethra is dissected up, a fine catheter inserted and over it the urethra is twisted through about 90 degrees and fixed by sutures (Gersuny's operation); in other cases paraffin wax may be injected into the tissue around the urethral orifice.

Urethrocele.—A red mass of prolapsed mucous membrane may protrude from the urethra of little girls, and is accompanied by incontinence. The excess of mucous membrane is destroyed by the cautery.

Abnormalities of the Female Genitals.

Persistent cloaca.—The normal anus is absent, and the rectum opens, guarded by a sphincter, within the posterior fourchette. It may be left alone in most cases.

Hypospadias.—Owing to the incomplete division of the urogenital sinus, the bladder appears to communicate with the vagina, and there is incontinence of urine; or there is no vagina, but the patient passes both urine and menstrual fluid through the urethra under the clitoris.

Epispadias and extroversion of the bladder is much rarer than in the male. The most extensive deformity shows the back wall of the bladder and trigone, with the urine escaping from the ureters, a gap in the position of the symphysis, and the labia wide apart. In the lesser deformity the urethra forms a groove opening on the vestibule and the clitoris is split. The *treatment* should be on the lines described for the male genitals.

Hypertrophy of the labia minora or nymphæ.—They may be so increased in size, especially in some tropical countries, as to hang down as pendulous vascular folds. *Treatment.*—Removal.

Atresia of the hymen.—The hymen may form a rigid ring resisting dilatation and rupture, or may present more than one small opening. It is generally incorrect to speak of imperforate hymen; it is nearly always the vagina, just above the hymen,

which is imperforate. When tags of a torn hymen remain inflamed they may be a cause of pain and spasm, dyspareunia. *Treatment.*—Notching and dilatation under an anæsthetic, also the removal of tags with the scissors or cautery.

Hermaphroditism.—The term is now used for individuals whose sex is, superficially at least, doubtful owing to arrest of development. There is no such thing as the occurrence in the same individual of the genital organs of both sexes, either anatomically or physiologically perfect. But an incomplete development is occasionally met with.

Male hermaphroditism is the most frequent anomaly. The patient is a male with an arrest of the external genitals which then resemble those of the female. The penis is stumpy like a clitoris, the urethra is in a condition of hypospadias, the floor being absent back to the orifice of the uterus masculinus, into which a probe may be passed. The scrotum is cleft and the prominences on either side contain the testes, from which run the vas deferens—often with some hernia. It is a grave practical error to mistake the child for a female.

Female hermaphroditism.—The clitoris may be excessively long, and this may be combined with labial adhesions and inguinal herniæ containing the ovary. The adhesions, however, will yield and expose the vagina, and a rectal examination will discover a uterus. There will also be other female characteristics. Thus the breast will be large, there will be an absence of hair on the face and chest, broad hips, etc.

Partial true hermaphroditism.—No real opinion can be given in this condition unless the organs supposed to be testes or ovaries can be examined microscopically. The naked eye appearances of partially developed organs are indistinguishable. The first rule in all cases of doubtful sex is to rear the child as a male, when inconveniences arising from the development of male characteristics as puberty is reached are avoided. This rule covers the majority; the remainder are practically sterile individuals, and whether a feminine male or a masculine female in general appearance it is far better to treat them as males. The second rule is to dissuade all such people from marriage.

Malformations of the vagina.—A double or septate vagina in part or for the whole of its extent is due to the two ducts of Müller not coalescing.

Rudimentary or defective vagina.—When this is attended by an absence of the uterus and ovaries as found by a finger in the rectum and a sound in the bladder, no trouble ensues until marriage, when a demand for a sufficient vagina arises or the urethra gets dilated and the woman suffers from incontinence. In such cases a pocket may be made by cutting and dilating between the bladder and rectum, avoiding a communication with either of these cavities.

Hæmatokolpos.—A horizontal septum closes the vagina immediately above the hymen, and the vagina above becomes distended at puberty by the collection of menstrual fluid, which causes a fluctuating

swelling to bulge between the labia, pushing the hymen in front of it. The patient has moliminia but no flow.

Hæmatometra and Hæmatosalpinx. — The distension by menstrual blood involves the cavity of the uterus and tubes as found on rectal bimanual examination, and a fluctuating tumour may rise out of the pelvis and distend the abdomen. A rupture may take place externally, followed by decomposition and septic absorption, or internally into the peritoneal cavity, followed by peritonitis. *Treatment.*—The vulva is most carefully cleansed, and then the septum is divided by a crucial incision, and the flow allowed to escape gradually into an antiseptic dressing, whilst the patient is kept rigidly in bed. If high up, a sound in the bladder and a finger in the rectum will serve as guides. Only when decomposition has set in should the cavity be irrigated, and then a double tube must be inserted, and a permanganate solution allowed to flow in at the lowest pressure with free opportunity to escape by the second tube, lest the fluid pass into the peritoneal cavity. Reunion must be prevented by gauze plugs or the passage of a bougie.

Diseases of the Vagina.

Vaginitis or Colpitis.—Under the term "leucorrhœa" discharges not only from the vagina but also from the urethra and uterus are generally included.

Acute vaginitis.—Gonorrhœal vaginitis occurs with inflammation of the urethra, vulva and cervix, but the latter are the more important. The pain is due to inflammation of the urethra, especially felt in passing water, and of the vulva, whilst the vagina is only a little swollen and discharges yellow muco-pus for a few days. The gonorrhœal vulvitis of children rarely extends to the vagina.

Puerperal vaginitis results from the injury and septic infection.

Membranous vaginitis with discharge of shreds occurs occasionally in the course of the exanthemata.

Further, acute vaginitis may be set up by the introduction of septic foreign bodies, instruments, and by injuries.

Chronic vaginitis may follow on the acute form. It may occur in connection with disturbances of general health, anæmia, etc., and is not an uncommon condition after the menopause and in old women. A careful examination is required, aided by a speculum, of the urethra, the vagina, the surface of the cervix, and of the discharges escaping from the uterus.

Complications.—Extension of the inflammation upwards to the uterus, tubes or peritoneum, to Bartholin's glands and to the urethra.

Treatment.—Acute inflammation is treated by rest, saline purge, warm hip baths, abstinence from alcohol, morphine suppositories, and frequent douching with permanganate. Chronic vaginitis is treated by improvement of the general health, and locally by astringent douches

of chloride of zinc, tannic acid, alum, or sponging with solutions of nitrate of silver.

Vaginal ulceration may be syphilitic in origin or the result of injury, introduction of unsuitable pessaries, and other foreign bodies. The *treatment* consists in removal of the cause, the use of astringent lotions and iodide of potassium, when due to syphilis.

Acquired vaginal stenosis is the result of ulceration. *Treatment.*—Rapid dilatation is carried out under an anæsthetic with the fingers, with or without notching with a knife. Less severe cases are dilated slowly by bougies.

Tumours of the vagina are all very rare. A *fibro-myoma*, sessile or pedunculated, may grow from the anterior wall between the urethra and anterior fornix. A *squamous-celled carcinoma* or epithelioma generally commences in the posterior vaginal fornix. A *glandular carcinoma* may be annular or involve the whole tube as a diffuse thickening. *Sarcomas* arise in young children as well as in adults, and may appear as polypoid grape-like masses.

Cysts of the vagina are occasionally, though rarely, met with as the result of the distension of the mucous follicles; and others are described as originating from remnants of Gartner's duct, or from the dilatation of lymphatics. They should be dissected out.

Vesico-vaginal fistulæ, when not due to malignant disease, are generally the result of sloughing, consequent upon the pressure of the child's head in a prolonged or instrumental labour, though they may be occasionally produced in other ways, as from the impaction of a foreign body in the vagina or urethra, injury, etc. They give rise to incontinence of urine, and are productive of great inconvenience. They may be so small as merely to admit a probe, or nearly the whole of the wall of the vagina may be destroyed. The common situation is just below the neck of the uterus. *Treatment.*—Where the fistula is very small, touching it with the actual cautery may succeed in closing it; but a plastic operation is usually necessary. The rectum having been cleared by an enema, the patient should be placed in the lithotomy position, and a duck-bill speculum introduced. The edges of the fistula should then be pared, the bladder separated from the vagina for a little around the ring, then the wall of the bladder is inverted and sutured, and afterwards the vaginal wall is everted towards the vagina and similarly united. Needles in handles or a needle-holder is necessary. The urine must be drawn off every six hours and the vagina gently douched.

Uretero-vaginal fistulæ of similar origin require the dissection up of the ureter above and its implantation into the bladder, either through the vagina or by laparotomy.

Recto-vaginal fistulæ are treated by inverting the rectal mucous membrane and everting the vagina after paring the edges. If they are extensive, the rectal sphincter should be stretched or divided backwards towards the coccyx, and the bowels moved daily.

Prolapse of the vagina results from general weakness, aggravated by overwork, pregnancy, and all causes of increased abdominal tension, such as constipation, over-distension of the bladder, cough, strain, etc.

Cystocele and *Rectocele* are the names given to a prolapse of the anterior and posterior wall of the vagina respectively. In the former the bladder of course protrudes; in the latter the rectum or the pouch of Douglas, which may contain some small intestine. Partial prolapse of either wall is a frequent accompaniment of extensive ruptures of the perineum, and require a plastic operation for their cure. Pessaries are first tried, and failing, a portion of mucous membrane from the anterior or posterior wall of the vagina as the case may be is removed, bringing the raw surfaces together with sutures, and keeping the bladder empty with a catheter till firm union has taken place.

DISEASES OF THE FALLOPIAN TUBE, OVARY AND BROAD LIGAMENT.

Salpingitis—Pyo-salpinx.—The Fallopian tube, as the result of inflammation, may become shut off from the uterine cavity by swelling

Fig. 532.—Double hydro-salpinx. B. Bladder. R. Rectum. R T. Right tube opened. L T. Left tube. O. Ovary. U. Uterus. (St. Bartholomew's Hospital Museum.)

of the mucous membrane and kinking (Fig. 532), or from the peritoneal cavity by adhesions of the fibriated extremity, which may be folded in and matted together or adherent over the ovary, especially when the ovary suppurates as well. Thus the tube may be distended and the ovary healthy or buried in adhesion, or the ovary, whether previously cystic or not, may be partly occupied by the abscess. The distended

tube may become as large as the fingers, or even a sausage, or may be bent on itself and one end especially dilated like a retort (Fig. 533). The *causes* are puerperal, gonorrhœal and tuberculous. In old standing cases the pus becomes thin and like mucus (so-called hydrosalpinx), or it may contain blood, either menstrual from acute congestion or because of suppuration in connection with an extra-uterine fœtation (hæmato-salpinx). The symptoms are pain—worse on standing and walking, straining and coitus—intensely painful, irregular or profuse menstruation, dysmenorrhœa, with or without a purulent discharge in the intervals. The febrile symptoms may be severe, with rigors, or slight and intermittent, but the patient tends to wasting and septic anæmia. An ovoid or sausage tumour may be detected on examination to one side of or behind the uterus (Fig. 532). There may be considerable mobility, or fixation owing to surrounding adhesions. *Treatment.*—Rest, hot douches, and iodide of potassium

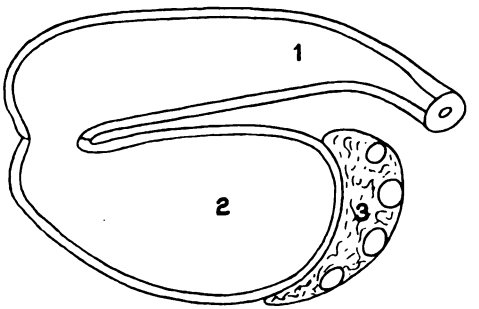


FIG. 533.—Diagram of a tubo-ovarian cyst or abscess, after Roberts. 1. The tube dilated. 2. The sac formed by adhesions of the fibriated end of the tube to the ovary. 3. Ovary.

is a successful line of treatment in early stages of salpingitis, but when pus has collected removal is required as early as possible. This should be done by abdominal section (see pp. 1077, 1081). A vaginal operation is altogether inferior, as largely involving working in the dark.

Pelvic cellulitis forming a parametric abscess begins in the broad ligament as the result of septic infection. It may follow gonorrhœa or puerperal fever, or an extra-uterine fœtation attended by rupture into the broad ligament. The abscess forms behind and to one side of the inflamed uterus, which it pushes over to the opposite side; as it increases it may point in the groin or rise up as far as the umbilicus in front of the peritoneum. It may burst into the bladder or rectum, at the umbilicus, or in the groin. *Treatment.*—A pelvic abscess should be opened, if possible, through the posterior vaginal fornix. An incision is made behind the cervix in the middle line, and a finger or forceps pushed upwards into the abscess cavity. An abdominal incision is only indicated when the abscess is not pointing

in the posterior fornix, but can be felt bimanually behind the abdominal wall. A vertical incision is then made through the outer fibres of the rectus, which are retracted, the transversalis fascia carefully opened with forceps, the bladder pushed inwards and backwards, and the fold of peritoneum upwards and outwards, whilst the finger works its way towards the resistance at the base of the broad ligament to the side of the uterus; the pus is wiped out and the cavity filled with gauze. Or a counter-opening may be made through Douglas's pouch into the posterior vaginal fornix. When healing has taken place or the cellulitis has resolved without suppuration, puckering results on that side and the cervix drawn over to it.

Pelvic peritonitis and abscess.—*Pelvic peritonitis* arises by septic extension directly from the fibriated extremity of a Fallopian tube, or through the wall of the uterus.

A *pelvic abscess* may be produced by the pus becoming encysted in Douglas's pouch. The roof of the abscess is formed by adherent intestines. It is first felt in Douglas's pouch by vaginal or rectal examination; it may then rise up above the pubes as far as the umbilicus where it may burst; or the adhesions may give way and a further peritoneal infection take place. *Treatment.*—If pointing, the abscess is best opened through the posterior vaginal fornix, but when there is an extension widely in the peritoneal cavity, an abdominal incision is required. The opening of the non-infected portion of the peritoneal cavity should be avoided, but if this happens it must be well protected by sponges before opening the abscess, which is disinfected and stuffed with gauze before removing the protecting sponges. Or, guided by a finger in the peritoneal cavity, it may be possible to open it through the vagina, so avoiding any communication between the abscess and the peritoneum.

Inflammation of the ovary, or oöphoritis, and inflammation around the ovary, or peri-oöphoritis, arises from the same causes as those producing inflammation of the uterus and tubes (p. 1071), and an abscess may form either in the substance of the ovary or in conjunction with the fibriated extremity of the tube. *Tuberculous disease of the ovary* is rare; it is sometimes primary, sometimes secondary. The ovary may remain *in situ* and become fixed by adhesion or involved with the tube in inflammation, or become prolapsed into Douglas's pouch. Pain is caused by pressure on abdominal or vaginal examination. An *ovary* may be *painful*, without being inflamed to any marked degree, during menstruation, as a neurosis, as a result of ill-health, and from congestion the result of prolapse. *Treatment.*—Rest, hot douches, tonics, and aperients. A painful, but to the naked eye healthy, ovary prolapsed into Douglas's pouch may be drawn up through an incision in the linea semilunaris and fixed to the parietal peritoneum. An extensively diseased ovary may be removed per vaginam or by laparotomy, but a bilateral removal should be avoided wherever possible.

Tumours of the Ovary, Broad Ligament, and Tube.

Ovarian tumours are generally cystic, less commonly solid. They grow towards the peritoneal cavity and become pedunculated, or into the broad ligament and are then sessile.

(A) **Solid tumours.**—*Fibromas* may grow from a corpus luteum scar, and show an arrangement of fibres in whorls and be encapsuled They have been termed fibromyomas, but true *fibromyomas* grow in the broad ligament and from the round ligament of the uterus. A *sarcoma* (spindle- or round-celled) is apt to be bilateral and rapidly malignant. It may also be secondary. *Carcinoma* of the ovary is rare, and is usually secondary to cancer of the uterus, but it may be primary and cylindrical-celled arising from the tubes of the paroöpheron.

Papilloma and *adenoma* grow inside the *Fallopian tube* and distend it with soft growth and a mucoid fluid. *Carcinoma* may be superimposed upon a papilloma or adenoma, or rarely arise primarily. The tubes are also involved secondarily to cancer of the uterus. Rare tumours, arising from the remains of the Wolffian body, in structure resembling the suprarenal capsule, have also been met in connection with the broad ligament.

(B) **Cysts** (Fig. 534).—(i.) *Multilocular ovarian cysts.* — The common ovarian cysts are multilocular; generally there is one chief cyst, and some smaller secondary cysts, which may be so small as to lie wholly within the wall of the large one. They contain a thick, ropy, albuminous, colloidal or jelly-like fluid, arising from degenerate Graafian follicles, affect the whole ovary, but are not liable to malignant disease. The complications which ensue are generally the result of the size of the cyst, and of the adhesions which it forms to the omentum or intestines; these adhesions are made much worse by tapping. They chiefly cause trouble by their size and compression of the large veins; they may undergo torsion of the pedicle, when gangrene and suppuration set in, with symptoms of acute strangulation. When small they may be quite detached by torsion of the pedicle, and then get a secondary connection with the omentum. In an uncomplicated case there is a good pedicle containing the ovarian artery and veins and the Fallopian tube (Fig. 536). (ii.) *Dermoid ovarian cysts.*—These are cysts of congenital origin growing in the oöphoron, although they may be latent until long after puberty. They are lined by true skin, containing abundant sebaceous glands, also hair follicles. The contents consist of sebaceous material, occasionally also imperfectly formed bones resembling the lower jaw, teeth, etc. These cysts are frequently bilateral, and have a special tendency to become the seat of malignant disease. They are generally pedunculated, indeed may be detached and transplanted to the omentum, occasionally they are sessile, and have to be shelled out of the broad ligament. (iii.) *Papillomatous broad ligament cysts.*—These cysts grow from tubular

remains of the Wolffian body, the paroöpheron, in the broad ligament or hilum of the ovary, and contain a thin non-albuminous fluid, with warty or cauliflower-like papillomas projecting from the inner wall. Indeed, the whole of the cyst may be filled by one of these growths. The cysts are bilateral, generally sessile, with the tube and ovary spread out on their wall. Secondary cysts and papillary masses burrow into the broad ligament, and also project from the surface. Papillomatous masses may likewise become scattered on the peritoneal surface. There is then a marked peritoneal exudation of fluid, so that ascites is rapidly developed. A mass can be felt bimanually on both sides, retaining some mobility, and this, with the

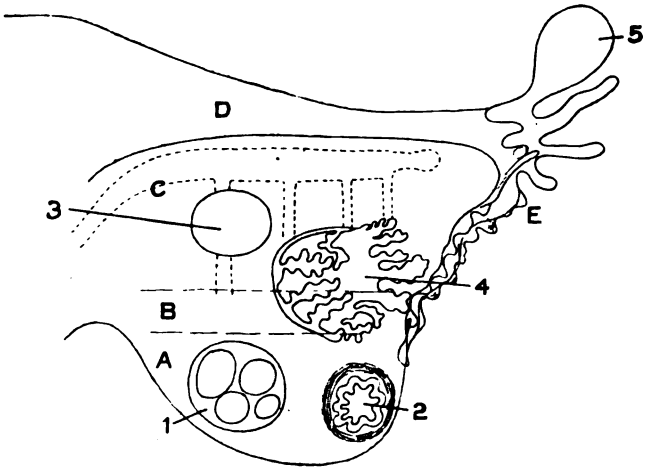


FIG. 534.—Origin of ovarian and broad ligament cysts. Diagram kindly revised by Mr. Alban Doran. A. Ovary or oöphoron. B. Hilum of ovary. C. Paroöpheron or parovarium. D. Tube. E. Fimbriæ. 1. Multilocular ovarian cyst. 2. Dermoid cyst. 3. Unilocular parovarian cyst. 4. Papilliferous cyst connected with parovarian tubules and prolongation of the fimbriæ. 5. Hydatid of Morgagni.

large amount of free fluid, serves for the diagnosis. A malignant growth is unilateral, more fixed and painful, and the patient suffers early from cachexia, but there is also free fluid in the peritoneum. When all the masses can be removed and shelled out from the broad ligament, and the peritoneal cavity has been well washed out, the prognosis is favourable, as the disease is only locally malignant.

(iv.) *Unilocular "parovarian" cysts* in the broad ligament.—The origin of these cysts is doubtful. They contain a watery non-albuminous fluid with only a small tendency to intracystic growths and no secondary cysts. The ovary and tube are not involved, and are spread out in the wall of the cyst. They often occur in young women, and may be bilateral. They were the only ovarian cysts which were cured by tapping. In removing them, the tube and ovary should

be separated and the cyst shelled out (Fig. 535). This is particularly important when the woman is young and the cysts bilateral.

General symptoms of ovarian cysts.—There may be none at first; but as the cyst increases in size, it gradually encroaches on the space normally allotted to the pelvic and abdominal viscera, giving rise to one or more of the following symptoms. Thus, from pressure on the bladder and rectum there may be frequent micturition and constipation; from pressure on the iliac vessels, œdema of the lower limbs and genitals; from pressure on the sacral and lumbar plexus, pains in the back, pudenda, and legs; from pressure on the stomach, nausea and vomiting; on the intestines, diarrhœa or colicky pains; on the portal vein, ascites and hæmorrhoids; on the kidneys and ureters, albuminous and highly-concentrated urine, rich in urates. Later, as the tumour extends upwards, there will

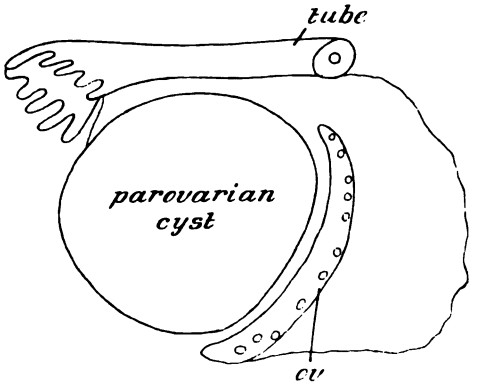


FIG. 535.—Parovarian cyst in the broad ligament unconnected with the ovary or tube.

be embarrassed breathing and dyspnœa from pressure on the heart and lungs; while finally emaciation sets in, and the patient dies of exhaustion, if not carried off by an intercurrent attack of peritonitis from rupture of the cyst.

The physical signs vary according to the size of the cyst, and the diagnosis at first may be attended with some difficulty. But as the cyst rises out of the pelvis, and the abdomen becomes gradually distended, the condition known as ovarian dropsy is produced, the physical signs of which somewhat resemble dropsy of the peritoneum (*ascites*) depending on visceral disease.

Summary of the differential diagnosis of ovarian from other abdominal tumours.

From a surgical point of view it is necessary to exclude certain conditions.

(1) *The distension of normal cavities*, the bladder with urine, the

uterus and vagina with menstrual blood, the intestines and rectum with fæces, the stomach with gas, because there are usually other methods of relieving the distension. In the case, however, of the gall-bladder or kidney this does not matter, as an operation is probably required. Of these conditions, the most important to exclude is the distended urinary bladder forming a tense swelling dull from the pubes upwards, with an upper globular outline. The swelling is removed by catheterism, although when drawn up the stiffer catheter may have to be passed in several inches.

(2) *Pregnancy in all its forms* except extra-uterine fœtation. It is especially difficult to diagnose a case of hydramnion from tumour of the ovary when the fœtus can be neither heard nor felt. (See a work on Midwifery.)

(3) *Phantom or false tumours*, formed by flatus, fat, and spasm of the abdominal wall (see p. 933).

(4) *Abdominal aneurysm* (see p. 402).

In other conditions that may be mistaken for ovarian tumours the importance of an exact diagnosis before operation is not great, as (except in the case of gummata in the neighbourhood of the liver, and when involving the abdominal cavity, also actinomycosis, both of which may be benefited by large doses of iodide of potassium) an operation is rendered desirable by the failure of medical means, and the first part of the operation is exploratory and the method of operating only decided on after opening the abdominal cavity. The apparent simplicity of a case may deceive the most experienced.

(5) *Ascites.*—In ascites the flanks are first distended and become dull, the percussion becoming resonant when the patient is turned to the opposite side, for the free fluid flows over; whereas an ovarian cyst rises out of the pelvis and distends the abdomen prominently in front, causing it to give a dull note on percussion, and the flanks are not distended until late and are resonant. A percussion wave or thrill is met with in both, but in ascites is all over, in the ovarian cyst over the dull area only. The upper limit of the dull area in an ovarian cyst is lowered and raised by the ascent and descent of the diaphragm in respiration. The ascites being caused by cirrhosis of the liver, malignant disease, etc., some special signs of these may be noted (see pp. 851, 852). In very advanced cases patients with large ovarian cyst develop swollen legs and genitals, and then the older name "ovarian dropsy" has some basis in fact.

(6) A *uterine fibroid* is generally accompanied by menorrhagia, a lengthening of the uterine cavity, and a drawing up of the cervix, and is median from the earlier stages (p. 1086). In the case of an ovarian cyst the menstruation is usually normal, also the length of the uterine cavity; the cervix is normal in position and there is nothing to be felt through the vaginal fornix except a tense resistance, which is at first lateral.

(7) *Hæmatocele from extra-uterine* fœtation has a sudden onset and forms a fixed pelvic mass, whereas an ovarian tumour grows steadily without incidents in the early stages and only becomes fixed when cancer arises (see p. 1095).

(8) *Pelvic inflammation, cellulitis, peritonitis,* and *pyosalpinx* present inflammatory symptoms, and arise from puerperal, gonorrhœal or tuberculous infection, whereas in the case of an ovarian cyst the tumour has existed before the inflammatory infection, or if suppuration follows torsion of the pedicle there are also signs of internal strangulation (see p. 1070).

(9) *Spleen, kidney and liver tumours* are likely to be confused with ovarian cysts only when displaced towards the pelvis, from which they can usually be returned when the patient lies down and the pelvis is raised. When, however, they become fixed by adhesions in the pelvis, also in the case of *hydatid, mesenteric* or *pancreatic* cysts, the diagnosis cannot generally be completed until the abdomen is opened.

Having, however, determined that the disease is an ovarian cyst, the next point to make out is whether it is unilocular or multilocular; free or adherent. The *multilocular* cyst is usually irregular; fluctuation is absent, or more marked in some parts than in others; and there is no thrill or fluctuation wave on percussion, unless one of the cysts has attained a preponderating size. The *unilocular* cyst is smooth, rounded, regular, and elastic; fluctuation is felt equally distributed over the whole of the dull area. If *adhesions are present* the cyst is fixed, unless they take the form of elongated bands, in which case a friction rub or sound may be felt or heard. The umbilicus moves with the cyst; but no movement is detected on examination by the rectum or vagina. If *there are no adhesions* the cyst moves on respiration, but the umbilicus does not move with the cyst, and the cyst is not found fixed on examination by the rectum or vagina. Such are the chief points to be attended to; but often the signs are delusive, and where a tumour is expected to be of a unilocular character and free, it may be found to be multilocular or solid and extensively adherent to the neighbouring parts.

Ovariotomy.—Under this heading may be included *Oöphorectomy* or the excision of ovaries unaltered or not markedly so; *Ovarian cystectomy,* or the excision of cysts to which the name of ovariotomy is especially attached; *Salpingectomy,* the excision of diseased and enlarged tubes; also the *shelling out of sessile tumours* from the broad ligament. An ovarian cyst should on no account be tapped through the abdominal wall, no useful purpose is served; if cases were ever cured by it they were rare instances of parovarian cyst. But the success of the removal has been often prevented or imperilled by the adhesions and septic complications set up by tapping.

The special preparations first used for ovariotomy are now in common use for all abdominal and other operations (see p. 180)

It is of great advantage for the patient to be on a table by which the pelvis can be raised (Trendelenburg's position) should it appear desirable when the abdomen is opened. The incisions should be made in the middle line (Fig. 407, p. 824), or slightly to one side through the rectus for not more than three inches midway between the umbilicus and pubes. Not longer at first, for such an incision is quite sufficient to draw out an emptied, pedunculated, free ovarian cyst; not lower, or the bladder may be wounded when drawn up by tumours, especially those of the uterus and broad ligament; not higher, for it unnecessarily weakens the region of the umbilicus and is not required unless a large solid tumour has to be got out. The peritoneum having been reached, and all hæmorrhage stopped with

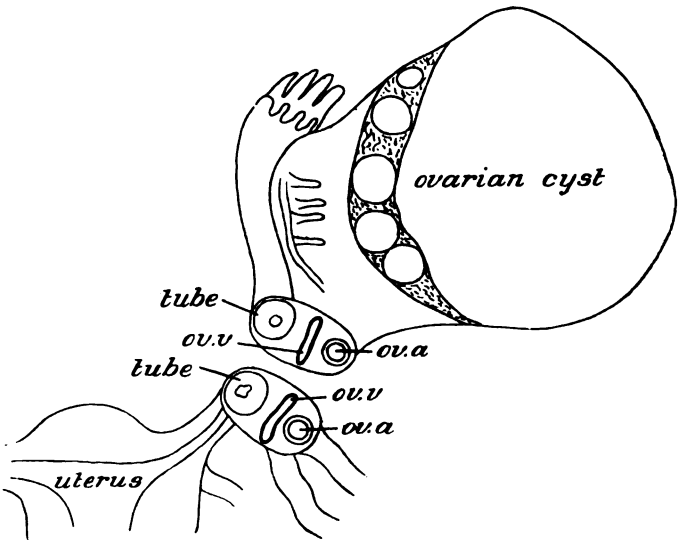


FIG. 536.—Diagram of the pedicle of a multilocular ovarian cyst. The pedicle is shown divided as when a ligature has been applied to allow the tube, ovarian artery, and vein to be seen.

pressure-forceps, the peritoneal cavity is carefully opened, the hand introduced, and adhesions felt for. If the cyst is free, Spencer Wells' trocar and cannula are thrust through the cyst-wall, the fluid evacuated, and the cyst gradually drawn out by Nélaton's cyst forceps through the wound as it is reduced in size by the escape of the fluid. The pedicle (Fig. 536) is now transfixed by a long needle armed with a ligature of silk, the ligature severed, and the needle withdrawn. The two portions of ligature are next interlocked, and the pedicle firmly tied on both sides (Figs. 86, 87, p. 214). Another may be placed round the whole pedicle. The pedicle is then divided on the cyst aspect, leaving a good frill to avoid slipping, and the cyst removed, care being taken to

prevent any of its contents escaping into the abdomen. If the cut surface of the pedicle (Fig. 536) appears dry, the ligatures by which it is tied are cut off short, and it is allowed to slip back into the pelvis; but if any bleeding point is seen, this must first be secured. Should adhesions be felt on opening the abdomen, they should be cautiously broken down by the hand, or divided after applying a ligature in the case of the omentum, care being taken not to injure the intestines and to secure all bleeding vessels. After the cyst has been removed, the other ovary should be examined, and, if diseased, also removed. The sponging-out or irrigation of the abdomen is needed only when fluid or blood has escaped into it, and must be continued as long as any blood-stained fluid can be squeezed from the sponges. The sponges should be thrust down deeply into Douglas's pouch,

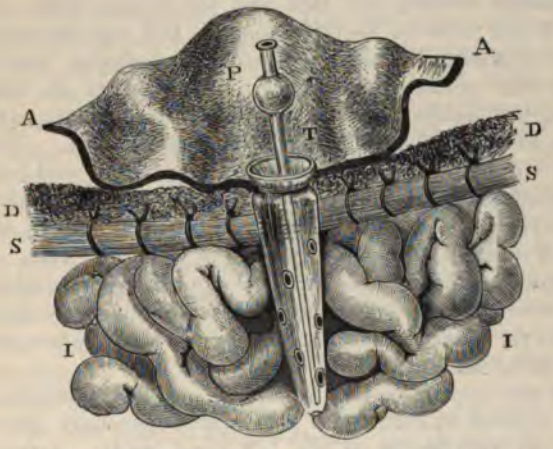


FIG. 537.—Method of draining after ovariotomy. AA. Rubber sheet. DD. Dressings. SS. Integuments. T. Drain-tube. II. Intestines. P. Pipette.

and when all the blood-stained fluid has been removed from this part of the peritoneum, a sponge attached by a string should be left there until just before closing the wound to ensure that no collection remains in this dependent situation. If irrigation is employed, an india-rubber tube attached to a can containing the irrigating fluid should be passed in various directions into the abdominal cavity, and the fluid allowed to flow until it runs away perfectly clear. The irrigating fluid may consist of boiled water at a temperature of 98 degrees, or water containing some mild antiseptic, as boric acid. A large flat sponge is finally placed over the surface of the intestines whilst the deep parietal sutures are being introduced. These should be passed about half an inch apart, and made to include the skin, peritoneum, and edge of the muscles (Fig. 74, p. 189), so that when tied two free surfaces of peritoneum are in contact.

The sutures being all *in situ*, the flat sponge and the sponge in Douglas's pouch are withdrawn, the instruments and sponges counted, and the wound closed by tying the sutures. Superficial sutures are then introduced between the deep to ensure the accurate apposition of the skin. An antiseptic gauze-dressing is next fixed over the wound by strips of strapping, and a broad flannel bandage applied. Under some circumstances, as where many adhesions have been broken down, and there is likely to be oozing into the pelvis, or where the peritoneum has been accidentally soiled by septic material of any kind, a drain-tube should be placed in the wound. The tube is passed through a tightly-fitting hole in the centre of a sheet of thin rubber (Fig. 537). The end of the tube should be then placed in the bottom of Douglas's pouch, and the parietal wound closed except at the situation of the tube, and dressed with antiseptic gauze placed between the skin and the rubber sheet. Over the mouth of the tube an aseptic sponge is laid, and the rubber sheet wrapped around it so as to prevent any discharge from the tube reaching the permanent dressing. The rubber is unfolded at intervals, the sponge removed, and a capillary pipette passed down the tube to draw off any discharge that has collected. The tube is retained till the discharge ceases to collect in it and become of a serous character. Many prefer to suture the abdominal wall in stages (see Fig. 75, p. 189) by continuous or interrupted sutures, also to use instead of a drainage-tube a long strip of iodoform gauze.

Modifications in the procedures are required—(*a*) for solid tumours and cysts which cannot be reduced in size; (*b*) for sessile and adherent tumours; (*c*) where suppuration has occurred; (*d*) where the disease appears to be malignant.

(*a*) If the tumour cannot be drawn out, the abdominal wall is quickly divided upwards and downwards, generally with scissors guarded by two fingers of the left hand inside. A free incision is much better than a small one which may have to be torn or bruised. Care must be taken not to injure the omentum, intestines or bladder, *e.g.*, during a forcible expiration.

(*b*) Sessile and adherent tumours are shelled out by blunt methods or careful dissection, the main principle being to keep close to the cyst wall and even to leave a little of the cyst wall adherent, *e.g.*, to a coil of intestines, and to return to it and dissect it carefully off at a later stage. At the same time every vessel or vascular band is clamped before dividing and later tied. In this way the two accidents, tearing into a viscus, the intestines or bladder, and the laceration of a deep-seated artery are avoided. In the case of the former accident the viscus is at once closed by a double row of sutures. If there is deep-seated hæmorrhage it is controlled by pressure with a hot sponge, the pelvis is raised, the intestines well packed back by sponges, a strong light thrown into the pelvis and long clamp forceps held ready to seize the vessel immediately the

sponge is removed. In cases of special difficulty a ligature on a needle is passed under the bleeding point and tied on one side and then the other, or the peritoneum is sutured over a raw, oozing surface, or the ovarian or uterine arteries are exposed behind the bleeding point, or an assistant's hand or sponge on a holder is pushed up the vagina or rectum so as to raise the bleeding point towards the operator. General oozing is controlled by steady pressure with a hot sponge for five minutes or so, or a strip of gauze is firmly packed in the pelvis against the bleeding surface and the end brought out of the abdominal wound. Nothing is more important than to ensure that no blood-clot remains or is afterwards effused. It is a frequent source of subsequent peritonitis.

(*c*) Where pus is suspected the pelvis should not be raised but the rest of the peritoneal cavity shut off with the greatest care before interfering with the tumour. If it can be removed any soiled surface should be wiped over with sponges saturated with carbolic acid 5 per cent. or perchloride of mercury 1 in 1,000, which is then swilled away with water, and a plug of iodoform gauze applied.

(*d*) Malignant disease being found, or suspected owing to the amount of deep-seated induration and fixation, it is rarely advisable to attempt removal, for damage is done by tearing, a large bleeding surface is left, removal may be incomplete, and the patient is very liable to shock. Even exploration should be conducted with great caution lest uncontrollable hæmorrhage ensue. Generally speaking, only a well-pedunculated malignant growth is at all suitable for removal, and that only when there are no signs of secondary tumours. On the other hand, the papilliferous cysts described above are suitable for removal.

Oöphorectomy may be required for inflammatory and cystic changes, and, on both sides, to arrest softening and allow of the bones hardening again in mollities ossium. It should seldom or never be done for neuralgia with no obvious changes in the ovary, certainly not on both sides. It has been done for profuse menorrhagia due to fibroids, to check hæmorrhage and diminish the size of the tumour, but is rarely successful, and the operation is apparently being supplanted by better methods. Removal of the ovaries has been followed in some cases by a temporary arrest of growth in inoperable cancer of the breast. The results are very uncertain, also the ages and kinds of cases most suitable. Generally no benefit follows, but the procedure may be considered admissible (see pp. 144, 154). In operating on pelvic tumours one ovary at least should be preserved if possible. The removal of two active ovaries is followed by disturbances such as occur at the climacteric, mental disturbances, melancholia, flushings, growth of hair on the face and chin, a deepening of the voice, and shrinkage of the breasts. A case in which both ovaries were removed for menorrhagia at twenty-three was thereby not only rendered barren but also dysmenorrhœa and

irregular menstrual flows, flushings and mental disturbance continued until forty-four, when cancer developed in the breast, requiring removal. Only after the climacteric had thereupon set in did the patient regain health. Thyroidin may relieve such symptoms, but excess must be avoided.

In *salpingectomy* especial care is needed not to rupture a pyosalpinx when freeing it, also the uterine stump will require to be treated by touching it with pure carbolic acid.

All *broad ligament tumours* have to be removed with special care lest the bladder and ureter be injured. The bladder may be outlined by passing a sound, or by filling and then emptying it.

After-treatment.—The patient is generally given nothing by the mouth for twenty-four hours except hot water. By the rectum nutrient enemata, with or without brandy, may be given when the patient is weak, and a pint or more of water to relieve thirst. Atropine and morphine may be administered hypodermically to relieve vomiting and pain and to obtain sleep. The catheter is passed at intervals after the first twelve hours. The bowels should be moved at the end of twenty-four hours by calomel in 5 grain doses, or in doses of a grain every hour, or sulphate of magnesia may be given in one dose or in small doses of a drachm every hour, or castor-oil (ʒij.) may be given as an enema. A movement of the bowels, however slight, is the best remedy for tympanites, and for threatened peritonitis. Relief may be also afforded by drops of oil of peppermint or of cajuput on sugar, or sips of equal parts of brandy and hot water, or by a turpentine enema, or the retention of a rectal tube. As soon as possible the patient returns to an ordinary diet. The sutures are removed after the eighth day. If the suturing is done in stages, the removal of the skin sutures is an unimportant matter. If deep interrupted sutures are removed on the eighth day the abdomen must be supported by strapping and firm bandaging. If not, the abdominal wall may give way during straining or cough and the bowel prolapse. Thyroid extract has been found to relieve symptoms due to the artificial menopause following bilateral oöphorectomy.

DISEASES OF THE UTERUS.

Prolapse of the uterus.—In combination with prolapse of the vaginal wall the uterus may descend so that the cervix or the whole organ lies outside the vulva, *procidentia uteri*, and may become irritated or inflamed. Prolapse of the rectum may simultaneously take place. *Treatment.*—Rest, tonics, aperients, pessaries and ensuring frequent micturition. These measures failing, one or other of the following operations may be done.

1. A longitudinal or transverse incision is made through the anterior vaginal fornix, *anterior colpotomy*, the uterus anteverted,

and sutures inserted well up on its fundus and then through the lower edges of the vaginal wound, so that on tightening the ligatures the uterus is fixed in a strongly anteverted position.

2. An incision may be made through the posterior fornix, *posterior colpotomy*, when the possible causation of the prolapse by a pelvic tumour can be excluded, adhesions can be broken down, and the uterus pushed up and afterwards supported by a pessary.

3. The round ligaments may be shortened by *Alexander's method.* The fibrous and fatty tissue in the abdominal ring is exposed, drawn forwards and the round ligament dissected up and drawn out, until taut, on each side. The ligament can be then sutured to the aponeurosis of the external oblique, or the two be tied together across the middle line under the skin. This operation cannot be done when there are pelvic adhesions unless the uterus be first freed by posterior colpotomy. Good results are obtained, and there has been freedom from trouble during pregnancy.

4. *Ventrofixation* is an operation now frequently performed. A short hypogastric incision is made so as to allow the fundus of the uterus to be drawn up to the wound, after breaking down adhesions, and it is then fixed in the parietal wound by kangaroo-tendon sutures, which do not penetrate to the uterine cavity, and over which the skin is sutured. The patient must be catheterised every four to six hours until the bladder can be easily and completely emptied. There is no danger if the operation is aseptic; the results as regards the prolapse are good; and pregnancy does not appear to be disturbed, although some prefer Alexander's operation when pregnancy is to be anticipated.

5. When prolapse is combined with ovarian cyst, the pedicle stump may be fixed in the abdominal wound by sutures, thus holding up the uterus, and the skin united over the stump.

Retroflexion and retroversion of the uterus.—The uterus is bent backwards on itself or rotates backwards as a whole so that the fundus presses on the rectum, causing irritation, venous congestion and piles, mucous discharge and constipation. The cervix then points forwards and upwards. When the uterus in this position is enlarged by pregnancy or by a fibroid tumour it becomes impacted in the pelvis, causing irritability of the bladder or more or less retention of urine and fæcal impaction. In extra-uterine fœtation the uterus is generally pressed downwards, the cervix approaching the vulva; there are irregular discharges of blood and less tendency to retention of urine. The uterus is replaced with the patient in the genu-pectoral position, with or without anæsthesia, and is then kept up by a pessary, whilst the bladder is periodically emptied by a catheter and the bowels freely moved. Relapsing cases may be treated as for prolapse.

Inversion of the uterus is generally brought about by dragging on the cord and placenta, but also by the descent of a submucous

polypus, or even of a malignant growth. A raw bleeding mass protrudes at the vulva, whilst on bimanual rectal examination the fundus of the uterus is found absent. Inversion of the uterus may be diagnosed by the uterus being turned inside out through the cervix, whereas a polypus has a pedicle which can be traced upwards into the uterine cavity, and a malignant disease of the cervix has the uterine canal in its centre. *Treatment.*—The inversion is reduced by steady manual pressure upwards, aided by counter-pressure on the hypogastrium or by an instrument, *e.g.*, Aveling's repositor, a cup fitting over the mass, and the constricting cervical ring may be divided by a posterior incision. After the climacteric vaginal hysterectomy may be best.

Examination of the uterus. — The cervix uteri may be examined *with the finger*, and the position and size of the body of the uterus and the general direction of the cavity made out bimanually, the finger in the vagina, then in the rectum, or in the rectum only when the hymen is intact; also in some cases a *bladder sound* may be passed. The cervix may also be inspected *through a speculum*, and can be fixed or drawn down during examinations and operations by a volsella or by a ligature passed through it. By combining drawing down with a bimanual examination, one finger being in the rectum, the upper part of the fundus and the appendages can be explored. A general idea of the size of the uterus and the direction of its cavity having been gained by bimanual examination, a more exact information as to the extent of the uterine cavity and its direction is got by passing a *uterine sound*. This is made of flexible copper or silver with a bulbous end, and is generally bent to an angle of 160 degrees about $2\frac{1}{2}$ inches from the end. It is first sterilised by boiling, carbolic acid or flaming. It is passed over the finger placed on the cervix, and by moving the handle in a circle and gentle manipulations it is made to slip in. It should be remembered that, especially when inflamed, after labour and in malignant disease, the uterine wall is so soft that the sound may easily perforate it or may enter a Fallopian tube. When pregnancy is suspected, the sound must not be passed except perhaps when there is good reason to believe the pregnancy to be extra-uterine. A better way in many cases is to pass a speculum in the dorsal position, fix the cervix with a speculum, and pass a gum elastic bougie, guided by the eye, the length of the bougie inserted being marked by the finger before withdrawing it.

Dilatation of the os is easy shortly after labour or abortion. It may be done slowly by inserting a tent into the cervical canal through a speculum, guided by the eye, after fixing the cervix with a volsella. The tent expands with moisture, and in twenty-four hours the canal may be further stretched by dilating bougies or the finger. Rapid dilatation is gently done with graduated bougies or expanding dilators, under an anæsthetic, avoiding tearing. The

interior is then explored with the finger, combined with hypogastric counter-pressure.

Preparation of the vagina previous to operations.—The vagina is first douched with permanganate lotion and then a speculum is passed. The cervical canal or the surface of a cancer or sloughing polypus may now be painted with pure carbolic acid or 1 in 500 perchloride of mercury, which is then swilled away. The vagina is next wiped out carefully with swabs soaked in perchloride of mercury, 1 in 1,000, and the speculum gradually withdrawn so as to bring all folds and pockets into view. All the mercury solution is now washed away with a douche of sterilised water and the vagina lightly filled with iodoform gauze.

Plugging the vagina for uterine hæmorrhage.—A speculum is passed up to the cervix, blood wiped away, then a strip of gauze is inserted into the cervix if patent, and packed firmly against the cervix and vaginal fornices. As the packing is continued the speculum is gradually withdrawn until the vulva is reached. Then a pad of wool is placed over the vulva and another on the hypogastrium, and firm pressure applied with a double spica bandage. The plug is changed after twenty-four hours, when usually a lighter packing will suffice.

Inflammation of the uterus.—This may affect the vaginal aspect of the cervix, the cervical canal, the cavity of the uterus (*endometritis*), or the body wall. The causes are *local*, septic puerperal and gonorrhœal infections, and *general*, impairment of health, febrile affections, syphilis and tubercle, these but rarely, and senile changes.

The cervix may be affected by *erosions*, and *superficial ulcerations* following fissure during labour. In itself the condition has not much importance, and it is a question whether the symptoms attributed to it of local pain radiating to the spine, etc., with slight discharge, are not rather symptoms of general debility. Its importance lies in being a possible source of epithelioma of the cervix, which generally occurs in married women. *Treatment.*—Improvement of the general health and simple douches. The application of caustics or of the cautery through a speculum is usually of no permanent value, and may possibly lead to cancer. Persistent erosions and ulcerating fissures indicate an excision of the affected part with the application of sutures, *trachelorrhaphy*, without narrowing the cervical canal. In extensive cases, the cervix should be amputated completely. It is of the greatest importance to anticipate by this operation the setting in of malignant disease.

The *cervix* may become *hypertrophied* and elongated so as to reach the vulva whilst the uterus remains in position. *Treatment.*—Amputation.

The uterine cavity.—The *cervical canal* is especially the seat of chronic gonorrhœal inflammation. The *uterine cavity* may become

distended by placental débris and moles with pus, the body remaining enlarged, *subinvolution;* or the mucous membrane may undergo chronic inflammation and hypertrophy into polypoid masses; or the uterus may be affected as a senile change (*senile endometritis*); the mucous membrane then degenerates and the body of the uterus shrinks, the discharge being thin, sanious, or purulent. Any uterine discharge must be examined for organisms, septic or gonorrhœal, and any fragment of curetted material for new growths, fœtal remnants, or sloughing fibroid.

Curetting the uterine cavity.—The patient being anæsthetised, the cervix fixed with a volsella and the os dilated, a blunt curette is gently used, and the cavity afterwards irrigated by a double-way cannula or Barker's flushing gouge. Or the cavity having been cleared and dried, may be swabbed out with pure carbolic acid or iodine liniment, all excess being afterwards washed away. Following labour, when inflamed or if malignant, the wall is most friable and easily perforated. The uterine cavity and vagina are finally filled with iodoform gauze, which is removed after twenty-four hours, and douching continued.

Septic infection of the uterus is generally puerperal, occasionally gonorrhœal, or it may be due to injury or rape. The venous sinuses and veins leading from or belonging to the cervix and uterine body, as also the lymphatics, become filled with septic thrombi which quickly form abscesses and extension occurs:—(1) To the broad ligament, causing septic œdema, pelvic cellulitis, or a parametric abscess. (2) To the tubes, causing septic retention (pyosalpinx), a tubo-ovarian abscess between the fibriated extremity of the Fallopian tube and the ovary, or suppuration in the ovary itself. (3) To the peritoneum through the wall of the uterus to the serous surface, or by leakage from the fibriated extremity of the tube. The pelvic peritonitis is limited and adhesive, or purulent, forming a pelvic retro-uterine or perimetric abscess in Douglas's pouch shut off by the intestines above. (4) Venous thrombosis. The iliac vein may become thrombosed, the thrombi by retrogression involving the femoral; if simple, this may be followed by chronic œdema of the limb, but it is generally septic, then causing phlegmasia alba dolens or white leg, which may develop into extensive septic cellulitis. (5) Septicæmia, pyæmia, septic pneumonia, endocarditis, multiple abscesses, etc. *Treatment.*—Whilst the septic inflammation is still confined to the interior of the uterus, prompt curetting (see above) may arrest extension.

Uterine fibrous tumours or fibroids.—These tumours are fibromyomas, of unstriped muscle and fibrous tissue, of unknown origin, but growing around blood-vessels (Fig. 538), and the fibres arranged into whorls and strands. They develop between the ages of thirty-five and forty-five, are exceptional before twenty-five, are not met with before puberty, and apparently always commence before the

climacteric. They grow very slowly, increasing temporarily with menstruation or from transient œdema; in a year they may become the size of a fœtal head, in three years the size of a man's head, or take twelve years to distend the abdomen to that of the size of pregnancy at term. They are liable to become cystic with or without hæmorrhages, and to inflammation and sloughing especially when projecting into the uterine cavity. Calcification and fatty degeneration ensue with shrinkage after the climacteric. Occasionally they become sarcomatous.

Symptoms.—A fibroid may grow to some size without being discovered. It then causes trouble by pressure and weight, also by

Fig. 538.—Fibromyoma of uterus. Photograph of a section through a tumour. An artery is shown cut transversely, around which has developed unstriped muscle fibres mixed with fibrous tissue. In the left half of the photograph the strands of fibres are cut through mainly in their long axis, in the right half chiefly transversely.

pressure on the ureters, causing hydronephrosis or even pyonephrosis, and when prolapsed into the pelvis difficult micturition or retention. Fibroids are a grave disturbance of pregnancy by giving rise to hæmorrhages and abortion followed by septic infection, or by obstructing labour. Moreover, during pregnancy they much increase in size. Recurrent or persistent menorrhagia may occur in the intramural and submucous form and cause profound anæmia.

Varieties of uterine fibrous tumours.—(1) The *subperitoneal tumours* protrude on the surface of the uterus, and can be felt bimanually. They may be sessile or pedunculated. They should as a rule be left alone unless they grow to a considerable size or cause pain. If pedunculated, they may be carefully ligatured and excised; if sessile,

shelled out from their capsule. (2) The *intramural tumour* gives rise to a general enlargement of the body of the uterus, which may steadily increase until the climacteric and then shrink. It may, however, after being stationary take on a rapid growth which points to a malignant change. Such a uterine fibroid early becomes unbearable in a young single woman. It is most important to exclude pregnancy. (3) The *submucous tumour* protrudes into the uterine cavity, and may pass through the cervix into the vagina. It is also called an *intra-uterine polypus*. A true mucous polypus is a pedunculated adenoma growing from the cervix, generally about the size of a pea.

The *treatment* consists at first of rest and iodide of potassium. For menorrhagia and intra-uterine polypus, the cervix is seized with a volsella, dilated, the pedicle of the polypus cut through, the interior of the uterus curetted and sloughing fibrous tumour scooped away, after which the cavity is firmly packed with gauze. For continuous hæmorrhage a ligature in continuity of the uterine arteries in the base of the broad ligament may be done through the vagina, on each side of the cervix, avoiding the ureters. Double oöphorectomy was frequently performed, but it has been mostly given up on account of the objections to inducing an artificial climacteric in a young woman. Besides, the operation may be useless.

Removal of the uterus is indicated for progressive enlargement and for pain. It has been shown that such symptoms may point to a malignant change. Recently the tendency in favour of removal of the fibroid has increased, and the expectant treatment is less strongly supported. Only when the woman is close upon the climacteric, and the uterus causes no further inconvenience than from its size, may an expectant treatment be adopted. In all cases where pregnancy has started it is very much safer to operate without delay.

Myomectomy is the excision of the fibroid, whether sub-peritoneal or intramural, by incising the peritoneum and capsule, shelling out the tumour, arresting all hæmorrhage by ligaturing, and then suturing the peritoneum over the exposed surface. Except for an intra-uterine polypus, and when the tumour bulges downwards into a capacious vagina, so that it can be exposed by cutting through the vaginal fornix, an abdominal operation should always be preferred.

Abdominal hysterectomy.—The two abdominal operations generally performed are (1) amputation through the cervix, (2) complete hysterectomy (panhysterectomy). (1) *Hysterectomy by amputation through the cervix.*—The extra-peritoneal treatment of the stump is now not used; it consisted in fixing the stump between the edges of the abdominal wall combined with the use of a serre-nœud. After specially preparing the vagina (p. 1085) and the abdominal wall, a sufficiently long incision is made to deliver the fibroid uterus, and this may mean the continuation of the incision far above the

umbilicus. The pelvis is then raised to the Trendelenburg position, and the broad ligaments are ligatured on either side internal to the ovaries which are spared when not also cystic. Anterior and posterior flaps of peritoneum are made and the bladder pushed forward. The uterine artery is ligatured as it runs up the side of the uterus, and the junction between the body and cervix cut through slowly, any vessels being clamped and tied. The cavity of the cervix is disinfected by a pledget of wool soaked in a strong antiseptic, and all bleeding having been stopped, the peritoneal flaps are sutured over the stump. The essential point is to arrest all hæmorrhage. This operation is considered by some to be easier and less severe than panhysterectomy. The objections raised against it

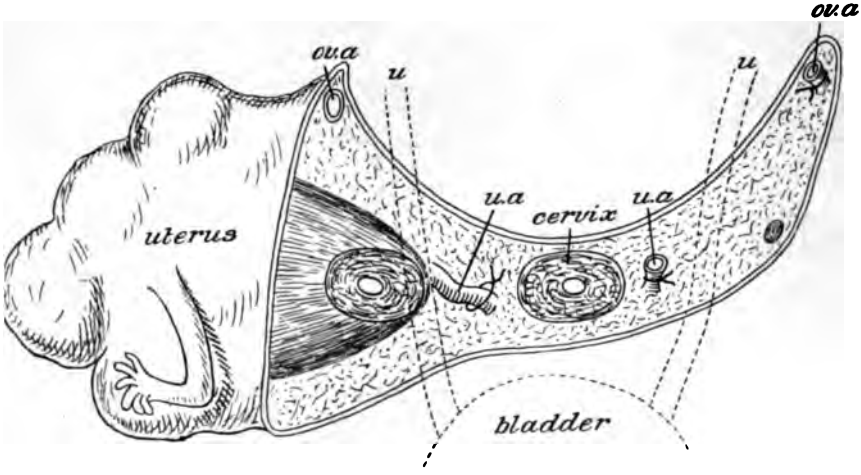


Fig. 539.—Hysterectomy by amputation of the uterus through the cervix (after Kelly). *ov. a.* Ovarian artery. *u.* Ureter. *ua.* Uterine artery.

are the obstruction presented by the cervix to drainage from the cavity behind the peritoneum, the greater liability to recurrent hæmorrhage, and the possibility of the stump becoming malignant.

Kelly's modification consists in commencing on one side whilst drawing the tumour over to the other (see Fig. 539). First the ovarian artery is tied, next the peritoneal flap is cut along the front and back of the uterus, the broad ligament opened, the uterine artery tied, the cervix cut across, when the opposite uterine artery can be seized close to the uterus and the ligature of the corresponding ovarian artery completes the operation.

(2) *Complete hysterectomy or panhysterectomy* is carried out (Fig. 540) after the ligature of the ovarian or broad ligaments, by drawing the tumour down over the pubes and cutting downwards a posterior peritoneal flap and clamping bleeding parts until the posterior vaginal

fornix is reached. Then the cervix is seized and pulled up in the direction of turning the tumour upside down (Fig. 540, B). This

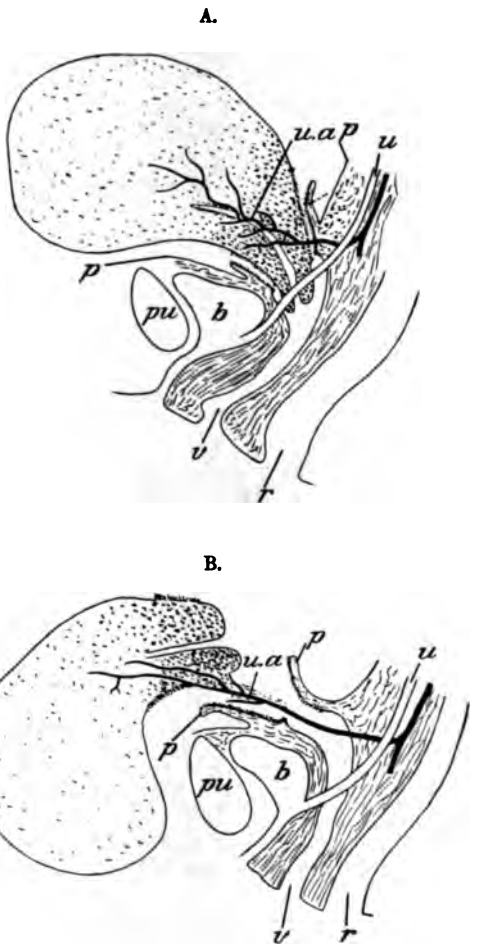


FIG. 540.—Panhysterectomy. Diagrams A and B to illustrate Doyen's method. *pu*. Pubes. *u*. Ureter. *b*. Bladder. *v*. Vagina. *r*. Rectum. *p*. Peritoneum, of which anterior and posterior flaps are made in A. In B the uterus is drawn forwards over the pubes, and *ua*. shows the uterine artery stretched out so as to be easily ligatured, whilst the ureter and bladder are pushed forwards and downwards out of the way.

makes the lateral vaginal fornices tense; clamp forceps are placed upon them close to the cervix and the lateral aspects of the cervix are then freed. By lifting up the cervix further the mucous membrane of the anterior vaginal fornix is divided in the same way, and

the finger can then push forward the bladder and ends of the ureters out of the way (Fig. 540, *b*, *u*). This hoisting up of the cervix now makes a band to appear running up on to the tumour, on either side, containing the uterine artery and its branches, which are thus secured easily. There remains the peritoneum upon the front of the tumour to be cut across above the contact with the bladder. A strip of gauze is next passed down the vagina from the peritoneal cavity, all vessels are carefully tied, the peritoneal flaps from the anterior, and the posterior aspects of the tumour are now united by a continuous suture across the pelvis so that the wound is completely shut off from the abdominal cavity. There remains the cleansing of the peritoneum, the removal of sponges, and the suturing of the wall. The *after-treatment* consists in drawing off the urine, taking out the plug from the vagina on the second or third day, and afterwards douching gently. This operation is to be preferred for its ease and the certainty with which the uterine arteries are secured, whilst the bladder and ureters are pushed forwards out of harm's way.

Cancer of the uterus.—*Squamous-celled carcinoma or epithelioma of the cervix uteri* forms with mammary cancer the commonest type of malignant disease in the female. *Causation.*—It is nearly always met with in women who have borne children; hence there is difficulty in avoiding the conclusion that its origin is connected with local irritation and old-standing fissures. *Symptoms.*—It is the earliest signs which are of importance, viz., a little blood-stained acrid discharge in a woman about forty, the vaginal surface of the cervix appearing superficially eroded or ulcerated with induration and irregularity of the margins of the os. Whenever this does not quickly disappear on rest and douching, it is imperative that a bit of the eroded part should be excised and examined microscopically. An examination should never be postponed on the plea of climacteric hæmorrhages, senile endometritis, etc. To wait for further signs is to place the case beyond cure. The cancer advances by ulceration and the formation of a warty growth; if chiefly the former, the cervix is rapidly excavated by an indurated foul ulcer; if the latter, then a warty foul cauliflower-like growth occupies the cervix—usually it is partly one, partly the other. The disease (Fig. 541) extends up the cervical canal, outwards into the base of the broad ligament, and then to the glands along the course of the internal common iliac arteries. A foul watery discharge, more or less blood-stained, escapes, and the patient suffers from pain owing to irritation and pressure on the pelvic nerves which later spreads down the thigh. The bladder is invaded and a vesico-vaginal fistula is set up. The ureters are involved, dilated, and tend to bring about obstructive suppression of urine. The sigmoid and rectum may be compressed and intestinal obstruction arise. Death occurs generally within a year of the disease being noted, from exhaustion and hæmorrhage.

Treatment by operation.—The following methods have been used.

(1) Supravaginal amputation of the cervix. (2) Vaginal hysterectomy, without or with removal of the adnexa. (3) Abdominal hysterectomy with removal of enlarged glands. (4) Sacral hysterectomy. (5) Suprapubic hysterectomy.

(1) *Supravaginal amputation of the cervix.*—This is the operation to be adopted in very early cases of erosion and commencing ulceration, which does not heal, even although the malignant disease is not yet confirmed microscopically. When the cervix is definitely involved the operation is insufficient and recurrence in the stump most probable; moreover the patient may afterwards suffer from dysmenorrhœa or hæmato-metra. The vagina is thoroughly disinfected, the cervix seized with a volsella and drawn down, the mucous membrane cut round with scissors, the lower branches of the uterine

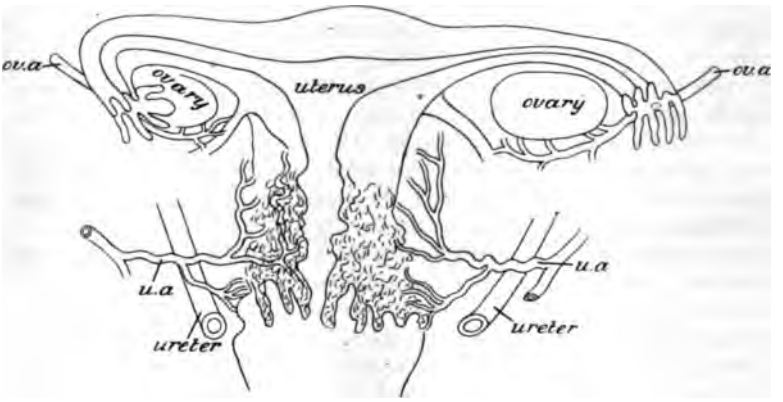


FIG. 541.—Diagram of carcinoma of the cervix uteri and its relations.
ov.a. Ovarian artery. *u.a.* Uterine artery.

artery (see Fig. 541) tied close to the uterus, and the cervix cut away with the scissors at the junction with the body. Bleeding is stopped by ligature or cautery, and then the vagina is packed with gauze.

(2) *Vaginal hysterectomy* is the operation for all cases in which there is very early malignant disease of the cervix. The immediate mortality of the operation has been reduced to 5 per cent.; the highest success reached has been a survival of 25 per cent. six years after the operation. Vaginal hysterectomy cannot be properly done unless the uterus can be drawn down by a volsella, and is contra-indicated when the broad ligaments are infiltrated. The procedures are the same as above, except that the peritoneal cavity is entered in front, after carefully pushing forward the bladder; then Douglas's pouch is opened. The uterine arteries are next tied by transfixing with ligatures the base of the broad ligament close to

the uterus; some use long clamp-forceps instead. The uterus is then drawn down further, the ovarian arteries are secured, and the uterus is cut away. At least one ovary should be left. The vagina is then filled with iodoform gauze, which is changed when saturated and the vagina douched. If clamp-forceps are left on, they may be removed after two or three days or be allowed to fall off. The chief danger of the operation is a wound of the ureter. This is avoided by pushing the bladder forwards, which carries the ureters with it; also by tying the uterine artery close to the uterus. The operation except in early cases is not in the end successful, because infiltrated portions of the broad ligament are left, as well as enlarged glands.

(3) *Abdominal hysterectomy with excision of the pelvic glands.*—Whereas in the two preceding operations the mortality has been reduced to a negligible quantity, the duration of life afterwards is on the average only a year in consequence of recurrence. On the analogy of the success obtained in cancer of the breast abdominal hysterectomy with removal of the contents of the pelvis and the lymphatic glands up to the iliac arteries has been advocated. But the operation has hitherto been attended by a considerable mortality or has been followed by recurrences, whilst cures have been altogether the exception. However, it is mainly the extensive cases that have been submitted to the operation, which may be said to be on trial. It should never be attempted unless there is good reason on preliminary abdominal exploration to believe that all the apparent disease and glands can be removed with a free margin by dissection, not by tearing or attempting to shell out; nor should it be done when the growth has already involved and dilated the ureters; also it may be said to be impracticable in a fat woman. The vagina is thoroughly prepared, and when the growth is fungating into the vagina it may be curetted, a strong antiseptic applied, and the vagina then packed with gauze. After making a short abdominal incision and exploring with the finger to confirm the practicability of the operation, the incision is enlarged up to the umbilicus, the pelvis well raised and the rest of the peritoneum guarded. The uterus is drawn up and held to one side whilst the opposite side is being dissected up. Commencing over the pelvic brim and the bifurcation of the iliac arteries, the peritoneum is raised, glands dissected up towards the growth and the ovarian artery clamped. If the patient has passed the climacteric both ovaries are removed; if not, one should be left if healthy. The ureter is now dissected up from the point where it crosses the iliac artery to the bladder by raising it on a hook without dissecting too closely to injure its proper blood supply. Then the uterine artery or the internal iliac itself, also the uterine veins, are carefully clamped until the vaginal fornix is reached, but the latter is not opened until the same procedure is completed on the opposite side. Finally, after dissecting up the trigone, as much of the upper part of the vagina is removed as to obtain a wide margin round the involved cervix.

Great care must be taken not to soil the abdomen with pus from the fungating growth. Some at this stage put the patient into the lithotomy position and finish the removal per vaginam. Thus all the disease, including the uterus, its appendages, pelvic fat and glands lying against the pelvic wall, are raised in one mass towards the roof of the vagina, the blood-vessels, ovarian and uterine having been secured, and important structures, the ureters and bladder, retracted at an early stage of the operation. The operation is now completed as in hysterectomy for myoma, more time having to be taken in securing bleeding points and suturing the peritoneum.

(4) *Sacral hysterectomy.*—This is an adaptation of the sacral operation for rectal cancer.

(5) *Suprapubic hysterectomy may be done through a transverse incision* without at first opening the peritoneum. It is very little employed.

Malignant disease of the body of the uterus is rare. A *columnar-celled carcinoma* may grow from the mucous membrane of the cervix—still more rarely from the mucous membrane of the uterine cavity. A *sarcoma* may grow in the wall of the uterus, sometimes in connection with pre-existing fibroids. *Deciduoma malignum* is a rapidly growing malignant disease of fœtal remains or an hydatid mole, and is classed as a sarcoma, or by some as a carcinoma or chorio-epithelioma. It is remarkable as exhibiting some very large cells, resembling the syncytial cells of the decidua, but these are not always present. *Renal and suprarenal tumours* are rare tumours in the uterine wall or adjacent broad ligament, recognised as developed in remnants of the Wolffian body. Some have an appearance resembling renal structure, whilst other tumours resemble the suprarenal capsule in character.

Symptoms.—A progressive enlargement of the body of the uterus, with early and profuse foul hæmorrhagic discharge. The os must be dilated, the interior explored with the finger, and material scraped away for examination. The diagnosis at this early stage has to be made from simple endometritis and from subinvolution after pregnancy. Although the microscopic examination prove for the time being negative as regards cancer, the case must be watched for diminution in the size of the fundus, for the material examined may have simply come from the surface of the growth which is meanwhile burrowing into the wall. In senile endometritis there is often much blood, but the uterus does not enlarge, and scrapings yield no proof of cancer. Progressive enlargement, even in the absence of microscopic evidence, *e.g.*, in the case of sarcoma, indicates an immediate operation. Later signs are fixation of the uterus, enlargement of pelvic glands, increasing pain and discharge, and the other signs mentioned for the cervical growth.

Treatment.—Abdominal hysterectomy will generally be more suitable than vaginal.

Palliative treatment of uterine cancer.—Unfortunately, owing to the late stage at which the disease is at present diagnosed, not more than 10 to 20 per cent. of the cases are operable when first seen by the surgeon. The disease can no longer be removed with a wide margin; there is already induration of the broad ligaments. The vagina must in such cases be frequently douched with permanganate solution, and dressed with iodoform and gauze. Fungating and sloughing masses may be painted with strong antiseptics, pure carbolic acid, perchloride of mercury, 1 in 500, immediately swilled away, or burnt down with the cautery, which is more under control than the liquid and fuming caustics, such as chloride of zinc, bromine, etc. Opium and morphine should be given freely.

Operations necessary owing to and in connection with pregnancy (see a work on Midwifery).

Labour being rendered dangerous by the co-existence of an *ovarian cyst, or uterine fibroid and uterine cancer*, it is now regarded as much safer to operate at once. The removal of an ovarian cyst need not disturb pregnancy at all. A sub-peritoneal fibroid may be shelled out without arresting the pregnancy. But even if abdominal hysterectomy has to be done, and so pregnancy finally put a stop to, yet this is much safer than for a woman to go on to term and labour commence, complicated by a large fibroid or malignant cervix; a viable child cannot be then expected, and the woman's life will most likely be sacrificed.

Ectopic gestation.—Extra-uterine fœtation.—The ovum is fertilised, and then arrested in its descent from unknown causes. The arrest takes place in the Fallopian tube, including the uterine horn, or exceptionally whilst still connected with the ovary previous to entering the tube, and one of several complications arises:—

(*a*) *Pelvic hæmatocele.*—This is a collection of blood in Douglas's pouch, owing generally to the leakage of blood from the fibriated extremity of the tube. Typically it is due to the extravasation of blood into the ovum, *apoplexy of the ovum*, which causes the ovum to swell, and blood escapes beside it, both into the peritoneal cavity and into the uterus, leakage being usually gradual and intermittent. The symptoms are recurrent attacks of pelvic pain, with at first a boggy sensation to touch in Douglas's pouch, which increases to form a pelvic tumour. The blood gradually becomes encysted, being covered in by matted intestines. Besides the pain there may be other abdominal symptoms, such as vomiting, with a slight rise of temperature. The blood which escapes by the vagina is not large in amount, and is dark and thick, whereas in abortion bright red blood is discharged copiously in gushes and forms clots. A hæmatocele is said sometimes to be purely menstrual in origin, but fœtal remnants are excluded with difficulty, and are often obscured by the clot. The ovum itself may be discharged by the uterus, or may be expelled into the peritoneal cavity and there disappear. With prolonged rest

the pelvic hæmatocele may be absorbed, and future pregnancies of a normal character occur. It may, however, become infected and suppurate, when an early incision is required, generally a vaginal one behind the cervix.

(*b*) *Rupture of Fallopian tube.*—When the ovum continues to develop in the tube the muscular wall does not hypertrophy like the uterine wall, but becomes thinned, and especially is this the case upon the part where the placenta comes to be placed. Thus before the third month rupture is inevitable. The rupture may take place primarily into the abdominal cavity, or in the first place between the layers of the broad ligament.

(*c*) *Diffuse intra-peritoneal hæmorrhage.*—*Signs.*—A woman likely to be pregnant, who has missed a period, or in whom the periods have become irregular, exceptionally without any menstrual irregularity, is suddenly seized with abdominal pain with or without vomiting, and feels extremely faint and ill. She quickly becomes more and more pale, whilst the abdomen becomes rigid and excessively tender. The pulse increases in frequency, and becomes more compressible, whilst there is no corresponding rise of temperature. She remains quite conscious, but is restless, sighs and yawns, then becomes absolutely blanched, pulseless, and sinks. A vaginal examination may detect a bloody discharge, also a boggy sensation in Douglas's pouch, and possibly, but not necessarily, free fluid may fill the flanks. Although a quiescent interval may follow the sudden attack, yet the increasing pulse-rate and pallor show that there must be no delay. *Treatment.*—The abdomen is opened as quickly as possible, the broad ligament and ovary are seized with the thumb and finger, and the bleeding point clamped. Then the clot is cleared out, the ruptured tube excised, the peritoneum cleared, and the abdomen closed. The patient must afterwards be treated for acute anæmia (see p. 207).

(*d*) *Rupture into the broad ligament.*—This happens when the wall of the tube gives way between the layers of the broad ligament, and a tumour forms to one side of the uterus. There the pregnancy may go on developing, or, the embryo dying, the tumour shrinks, or suppurates. If it continues to develop a further rupture may occur into the peritoneal cavity, and the placenta get a fresh attachment to the intestines, or go on to term, when the fœtus dies and becomes mummified or calcified into a lithopædion, or the sac suppurates, and from a pelvic abscess the bones of a macerated fœtus are discharged either on the surface or by the bladder, vagina or intestine. The diagnosis of this form of extra-uterine fœtation must at first be made from a tumour of the broad ligament, and later from a normal pregnancy (see a work on Obstetric Medicine). *Treatment.*—As soon as the diagnosis is made an operation should be performed. Whenever possible the ovarian artery is secured, and the sac, including the fœtus, shelled out from the broad ligament. In advanced pregnancy the sac is laid open, the

fœtus and placenta quickly removed, and the sac stuffed firmly with gauze; or the placenta may be left under the gauze packing to slough and come away later on.

Cæsarean section.—When this operation has to be done it is better to operate at term rather than to wait until the commencement of labour, when it must be hurried; worst of all is the waiting until the patient is worn out by the labour and the child nearly dead. The uterus will contract well enough, if the patient is not already exhausted. After drawing off the urine an incision is made in the middle line above the pubes; the wall of the uterus should be met with in front of the raised peritoneum. If the peritoneal cavity is opened it must be protected by sponges. The assistant presses in the patient's sides so as to keep the uterus in the wound, then a short cut is made into the cavity, the fingers inserted, and the cut rapidly enlarged in the middle of the fundus by scissors, a better plan than tearing. The child is next seized by the legs and extracted, the cord clamped in two places and divided between; then the placenta is scooped out and the uterus at once forcibly squeezed to make it contract. When the head is already wedged in the pelvis, forcible traction is made on the shoulders, and an assistant may even push up from below. Whilst the assistant presses on the edges of the uterine wound, interrupted sutures are quickly inserted through the whole thickness of the muscular wall, without penetrating to the mucous surface. When tightened the sutures form the best means of stopping hæmorrhage. Before this it should be ascertained that all the placenta has been removed, that the cervix is patent, and that all clots have been squeezed out of the uterine cavity. Then the abdominal wound is closed, a light gauze plug inserted into the vagina, and the child put to the breast to keep up the uterine contractions. If the child is already dead and the uterine cavity septic, or if the body of the uterus is affected by myoma, or there is cancer occupying the cervix, it may be safer to rapidly amputate through the cervix (Porro's operation). The extra-peritoneal method may be used for the sake of speed. The thick wire of a serre-nœud is passed round the neck of the mass, broad ligaments and all, but not low enough to include the bladder, whilst the uterus is drawn forwards and the intestines kept out of the way. The wire is tightened as much as possible short of cutting, two pins are passed through the stump on the *distal* side of the wire, and then the uterus is removed at one cut beyond the pins. The stump is fitted into the lower angle of the wound, and if there is time the peritoneum is united round the stump on the *proximal* side of the serre-nœud, the pins are capped and gauze slipped beneath them, and the abdominal wall is sutured above the stump. Much attention is required subsequently: (1) To tightening the wire periodically, without cutting through rapidly, in order to avoid recurrent hæmorrhage. (2) To dressing the

stump, which after the serre-nœud and pins have come away retracts and leaves a troublesome sinus, taking about six weeks to heal. (3) To catheterising the bladder, which the stump unduly confines. Whenever there is time, an intra-peritoneal method should be adopted.

In Cæsarean section the ovaries should not be removed, nor the tubes ligatured or resected; the *intentional* prevention of future pregnancies is no business of the surgeon. Indeed, patients have had Cæsarean section done more than once quite successfully; also subsequent deliveries have been accomplished without resorting to it, in particular by carefully inducing premature labour at the proper time.

Symphysiotomy.—The symphysis pubes may be divided during labour rendered difficult by a narrow pelvis. The pubic skin must be made aseptic by shaving, and by scrubbing with an antiseptic. Then through a short incision a blunt-topped bistoury is passed down behind the symphysis, the cartilage divided by cutting forwards, and the iliac spines pressed on so as gently to separate the symphysis. Then the wound is covered, and the child turned and extracted. Great care must be taken to keep the wound aseptic; it should be closely sutured and sealed with collodion. The hips are then compressed by a binder, and the woman kept on her back, and the urine drawn off until there is firm union. The urethra may be injured if the symphysis is too forcibly separated. *Complications.*—Suppuration, necrosis, and non-union of the symphysis.

DISEASES OF THE BREAST.

Abnormalities of the nipples.—*Congenital retraction of the nipple.*—The nipple may be unduly depressed; the breast is then usually an ill-formed one; and retention caused by imperfectly formed ducts, chronic inflammations and malignant disease often arise. The child cannot suck well, and fissures and eczema frequently follow. *Treatment.*—A semilunar piece of skin has been excised from the breast above and below the nipple and the gap sutured so as to make the nipple protrude.

Supernumerary nipples are soft warty projections containing tubular, not racemose, glands after the type of sweat glands, and are found along the pectoral border between the breast and axilla. They are liable to suppuration and tumour growth, so they should be excised.

Cracks and irritable nipples occur from prolonged suckling and want of cleanliness. Retention and suppuration may follow.

Paget's disease of the nipple, sometimes spoken of as eczema, is an intractable form of ulceration around the nipple. It lasts for many years, and yields to no treatment. A considerable proportion of cases develop squamous-celled carcinoma or epithelioma of the

nipple. The axillary glands then enlarge. *Treatment.*—When all mild measures are unavailing, amputation of the breast should be done for fear of cancer subsequently forming.

Neuralgia of the breast is not uncommon in young unmarried women, and appears to be frequently due to some ovarian disturbance. The pain is often severe, perhaps shooting down the arm, and may be constant or periodic; whilst the skin over the breast, as well as the gland itself, is exceedingly sensitive on handling. Nothing, except at times a slight fulness, can be detected on examination. The *treatment* consists in improving the general health by tonics, cold baths, and outdoor exercise, and in regulating menstruation. No local treatment is necessary; indeed, the patient's attention should be taken off the breast as much as possible.

Inflammation of the breast (*mastitis*) may occur at any age, and in the male as well as the female. In *infants* it is sometimes attended with a serous or milky discharge from the nipple, and is often made worse by ignorant nurses applying friction to "rub away the milk." *At or about puberty* it is met with in boys as well as in girls, but more frequently in the latter. Often, beyond the patient appearing somewhat out of health, no cause can be discovered, although in hospital patients a history of a blow is not uncommon. The inflammation may clear up, or terminate in an abscess.

Acute inflammation (*acute mastitis*), however, most frequently occurs during *lactation*, especially in primiparæ, and generally during the first month after parturition. It then appears to be most often due to the irritation of the nipple by the child sucking, particularly when the nipple is shrunken or retracted, or is in a cracked condition. Occasionally it is the result of excessive secretion of milk, and consequent distension of the ducts; or it may not appear till later during the period of lactation, when the patient's powers have been pulled down by long suckling. The essential cause is of course the presence of pyogenic cocci, which may gain access by the blood, the lymphatics, a sore nipple, or the lacteal ducts, the last being the most common.

Symptoms.—A feeling of uneasiness in the breast, then a chill or slight rigor, followed by fever and the local signs of inflammation, and often subsequently by abscess.

Treatment.—The breast should be placed at perfect rest by slinging it in a silk handkerchief passed over the shoulder, and by taking away the infant from the sound as well as from the affected side; the milk, if the tension is great, should be drawn off regularly by the breast-pump; and belladonna and glycerine applied to diminish the secretion, and opium or poppy fomentations to relieve pain. If it still remains full the breast should be taken in both hands and firmly squeezed, if necessary under nitrous oxide gas, by which curdy plugs and milk are expressed, with the result that suppuration is prevented or much restricted. Signs of abscess must be watched for

between them and the breast. Inunction with iodide of potassium ointment, or with oleate of mercury, and strapping the breast, are also recommended. Whatever treatment is adopted, it should be persevered in for a month or two only, after which excision of the tumour should be advised.

Hypertrophy of the breast.—There is a condition of hypertrophy often met with in lads about the age of puberty and in girls a little below that age. The breast enlarges slowly, often painlessly, generally on one, sometimes on both sides without marked signs of inflammation. Under the influence of a belladonna plaster applied for some months, which probably owes its efficacy to the fact that it prevents the patient irritating the breast by constantly feeling it, the hypertrophy may subside. It is of a chronic inflammatory nature, the chief increase consisting of interstitial fibrous tissue.

An enormous dependent tumour may form with venous congestion and ulceration of the surface, and may attain such a size that the patient bends under the weight. Fat women, but also thin, ill-nourished, anæmic patients may suffer from a gradual increase of fatty tissue. *Treatment.*—Suspending the breast in a sling over the shoulder, or if the enlargement is excessive, removal.

Prolapse of the breast.—The breast may become dependent and flattened even at an early age. In many races long suckling causes the breast to hang down like an empty bag. Some affirm that the women suffer less often from cancer in consequence of the breast being thus "sucked out." In young women desiring to wear low dress, the breasts have been fixed up in position by a Y-shaped incision, the leg of the Y running up to the axilla, and the arms stretching into the breast above and below the nipple.

Multiple cystic disease of the breast is an occasional termination of chronic lobular mastitis. One or more of the small cysts found in this disease become enlarged and filled with a yellow or brownish-yellow serous or mucoid fluid. They give rise to a distinct tense, elastic, hard, smooth swelling or swellings in the breast, whilst smaller swellings due to the smaller cysts may be felt scattered through its substance. Both breasts are frequently affected simultaneously. The larger cysts may be dissected out, but usually the whole breast may with advantage be removed.

Tuberculous disease is not so very uncommon. In appearance it resembles somewhat chronic mastitis, for which it is often mistaken. The formation usually takes place in or around an acinus, increases somewhat rapidly in size, and finally, after degenerating into a caseating mass, breaks down and discharges. When suppuration has been established, sinuses extend through the breast in all directions unless promptly treated. The milk secreted by a tuberculous breast contains numerous tubercle bacilli. *Treatment.*—This depends upon the age of the patient. If old and beyond the child-bearing period, the treatment may be confined to

opening the abscesses when they form, and slitting up and scraping such sinuses as may exist, while at the same time a good nourishing diet is enjoined, together with the internal administration of cod-liver oil and tonics. Should, however, the patient be a young woman, who has borne and is still capable of bearing children, the safest plan is to amputate the breast to safeguard any future child from infection by tubercle bacilli.

Syphilis of the breast.—The primary, secondary and tertiary forms of syphilis are all found affecting the breast. The *primary sore* usually takes the form of a painless fissure which refuses to heal, and is followed by enlarged axillary glands and secondary symptoms. It is occasioned through suckling a syphilitic infant, and is found upon the nipple of the wet nurse, and not upon that of the mother of a child the subject of hereditary syphilis. It is to be distinguished from a vaccine pustule derived from the child's arm, which while causing an enlargement of the axillary glands runs its usual course. During the *secondary stage* of syphilis, condylomata are sometimes found upon the nipple and areola. They have the appearance of condylomata elsewhere, and are highly infecting. The *tertiary form* of the disease appears as gummatous deposits, and is rare. The gummata occur as well-defined, circumscribed, hard, painless masses, increasing more or less rapidly in size and tending eventually to soften and break down into characteristic tertiary ulcers. They have to be diagnosed from tuberculous disease, chronic mastitis, and scirrhous carcinoma.

Tumours of the breast (see *General Pathology*, p. 116).—The tumour by far the most frequently met with in this situation is the acinous carcinoma (*scirrhus*), which is due to the proliferation of the epithelium lining the acini or the small ducts. Certain of the connective-tissue tumours (*fibromata*, *sarcomata*), springing from the periacinous connective tissue, are also of frequent occurrence. They seldom, however, occur pure, but are nearly always mixed with elements resembling the tissue of the breast itself (*adenomatous tissue*), and hence are spoken of as adeno-fibroma, adeno-sarcoma, adeno-myxoma. Whether these adenomatous elements are the normal breast tissue which has become surrounded and enclosed in the fibrous or sarcomatous growth as the case may be, or whether it is an abortive formation of the gland-tissue, has been a subject of controversy. More rarely the gland-tissue constitutes the chief bulk of the tumour (*pure adenoma*). The tumours composing this class were formerly spoken of collectively as *chronic mammary glandular tumours*. At times cysts are developed in connection with them, and they are then designated *cystic adeno-fibroma*, *cystic adeno-sarcoma*, *cystic adeno-myxoma*, etc. Various other forms of tumour, viz., tumours composed of fat, cartilage, vessel-tissue, nerve-tissue, etc., have also been met with in the breast, but are exceedingly rare.

for a papilliferous duct cyst involving the nipple, and for cysts in connection with tumours, especially the carcinomatous cyst of elderly people.

Pure sarcomata.—All forms of sarcoma may occur in the breast, the large-spindle-celled variety being the most common. The presence of the included breast-tissue, glandular or fibrous, or the degenerations, myxomatous and cystic, have given origin to compound names—adeno-sarcoma, fibro-sarcoma, myxo-sarcoma, cystic sarcoma, but it is the sarcomatous element which is the ruling factor. Sarcomata are most frequent between the ages of twenty and thirty-five. They begin in the periacinous and peritubular connective tissue, and at first are encapsuled, but later they infiltrate the surrounding parts and may perforate the skin and fungate. Their malignancy depends upon their structure, the round-celled and large-spindle-celled being highly malignant, the small-spindle-celled much less so; indeed the latter may recur again and again *in situ* before finally becoming disseminated, or their tendency to recurrence may completely wear itself out. The small-spindle-celled is usually firm, and on section greyish-white, smooth and succulent. The round-celled and large-spindle-celled are soft and elastic, owing to their richness in cells and blood-vessels and their scanty amount of intercellular substance. On section they appear of a pinkish-white colour, often blotched with blood, while cysts from hæmorrhages and mucoid softening sometimes occur in them.

Signs.—They form smooth elastic tumours, oval or rounded in shape, and are lobed or bossed when cystic; whilst the veins of the breast are often enlarged and tortuous. They grow rapidly, and may perforate the skin and protrude as a fungus; but, unlike carcinoma they do not infiltrate the skin or cause retraction of the nipple, and the glands are only in the more malignant cases enlarged. The tumour, moreover, is commonly larger than scirrhus, and the patient's age below that at which carcinoma is usually met with.

The only effectual *treatment* is the removal of the whole breast. If there is any doubt whether the tumour is a fibroma or a sarcoma it is better to have the consent of the patient before the operation for the removal of the whole breast, should the tumour, when cut into, appear to have malignant characters. When the axillary glands are enlarging, the operation is the same as that for carcinoma.

Carcinoma of the breast may occur as—(A) Spheroidal-celled, glandular, or acinous cancer, originating in the epithelium lining the acini. This is the most usual type of cancer of the breast. The varieties are: the hard or scirrhous, when there is much fibrous tissue; the soft or medullary, when it consists mainly of epithelial tissue. Colloid or cystic degeneration may also occur in connection with either form. These varieties do not correspond to variations in malignancy. (B) Columnar-celled, villous, or duct cancer, originating in the ducts, and showing much less malignancy

than the spheroidal-celled form. (C) Squamous-celled carcinoma, or epithelioma, growing on the surface of the nipple.

A. **Spheroidal-celled, glandular, acinous carcinoma.**— 1. *Scirrhous carcinoma.* — *Pathology.* — Scirrhus of the breast generally appears as an indurated, nodular, non-encapsuled, tuberous mass, of moderate dimensions, with long processes extending in various directions into the gland-substance and the fatty tissue around, and later, involving the skin and subjacent pectoral muscle. On section (Fig. 543) the tumour gives a characteristic creaking sensation to the knife, and the cut surface appears slightly concave from the contraction and shrinking of its fibrous stroma thus set free from the traction of surrounding tissues. It is of a hard resisting consistency, of a uniform close texture, semi-translucent, of a greyish-white colour often tinged with pink, and has been likened to the section of a potato or unripe pear. Sometimes it is intersected in every direction by short, wavy, glistening white fibres, with here and there yellow dots and streaks due to section of the epithelial columns which have undergone fatty degeneration; whilst in other places little masses of the surrounding fatty tissue and of muscle are seen enclosed by the processes of the growth; and patches of caseous-looking material or white creamy fluid, due to the growth having surrounded some of the ducts which have become only partially obliterated, may be scattered through its substance. The section on scraping yields a juice containing cells, free nuclei, and granular material.

Fig. 543.—Scirrhous carcinoma of the breast. (St. Bartholomew's Hospital Museum.)

Signs.—Scirrhous carcinoma generally begins as a small hard lump in the substance of the breast; it grows slowly at first, afterwards more rapidly, and then involves the skin and pectoral muscle; finally the skin gives way, and a foul ulcer is produced. In the meantime, the lymphatic glands in the axilla become involved, which as they increase in size press upon the axillary vein and brachial plexus of nerves, producing œdema of the arm and intense neuralgic pain. Later the cancer becomes disseminated through the internal organs and tissues of the body. The health, which on the first

appearance of the growth is generally good, now gives way, and as septic absorption from the foul ulcer occurs, the skin becomes sallow and earthy in appearance, the patient wasted, and cancerous cachexia is said to be present. The foul and profuse discharge from the ulcer, the absorption of septic products, the intense pain, the mental suffering, and the implication of internal organs, lead to exhaustion, and death soon steps in to put an end to the patient's misery. Such is a brief outline of the course of the disease when not subjected to surgical interference. Let us now study the characters of the tumour as presented in a typical case. It is usually situated in the upper and outward quadrant of the breast, or just behind or below the nipple. Its surface is hard and irregular, its margins ill-defined. The skin at first, when gently pinched up between the finger and thumb, shows a slight dimpling, and later appears distinctly puckered and unmistakably adherent to the growth. In the earlier stages the tumour glides freely over the pectoral muscle; later a slight resistance is felt on moving it from side to side; whilst finally it becomes firmly fixed to the walls of the chest. The nipple, when the growth is behind it, is retracted, in consequence of the traction which is made by the carcinoma upon the lacteal ducts (Fig. 543); but when the growth is situated in the circumference of the breast, there may be no retraction, or the retraction may occur only on one side; whilst when the cancer begins as an infiltration of the nipple itself, the latter will be harder and more prominent than natural. On raising the arm and drawing the finger-tips transversely across the inner side of the axilla, a hard cord or cords—infiltrated lymphatic vessels (Fig. 50, p. 140)—may often be felt extending from the tumour into the axilla, while in the space itself large glands will be discovered if the case is sufficiently advanced. The glands are at first single and distinct, later matted together, forming an indurated irregular mass, which is often adherent to the chest-walls, and in advanced cases extends as high as can be felt beneath the clavicle. In the supraclavicular space the enlarged glands may sometimes be detected, first as a mere fulness, subsequently as distinct swellings. After the skin over the tumour has given way, an ulcer with sinuous, irregular, everted, and indurated edges, and a foul, cavernous, irregular, and indurated base is formed, from which is exuded a foul-smelling and sanious discharge. The skin around is indurated from infiltration with the growth; or distinct, circumscribed, hard nodules of carcinoma are scattered here and there through it.

Diagnosis.—When the above signs are present there is no difficulty in pronouncing as to the nature of the disease. In the earlier stages, however, whilst the tumour is still small and has not yet become adherent to the skin or to the pectoral muscle, where the breast is large and there is no retraction of the nipple and as yet there is no enlargement of the axillary glands, the

diagnosis from an innocent tumour, a chronic abscess, a tense cyst, or lobular inflammation will be, to say the least, difficult. The age of the patient, the rate of growth, and the history of the case must then, to a great extent, be relied on for distinguishing it. But where the patient, as is occasionally the case, is young, the diagnosis may then be impossible without making an incision into the growth, a proceeding which, under such circumstances, after the difficulty has been explained to the patient, is not only justifiable but imperatively called for.

Rarer forms of scirrhus in the breast are occasionally met with. Thus—1. The cancer may begin as a general infiltration of the entire gland, when its course is usually very rapid; 2, it may chiefly affect the lymphatics of the skin, the whole side of the chest in such a case becoming infiltrated, hard, brawny and leathery in consistency, a condition known as "hide-bound," or "*en cuirasse*"; 3, it may begin as an infiltration of the nipple, or may be engrafted upon chronic eczema around the nipple; 4, in elderly women it may run a very chronic course, often remaining stationary, if not interfered with, for many years (*fibrous, atrophic or chronic cancer*); 5, it may occur in women as young as twenty and generally below thirty-five, grow with extreme rapidity, early affect the glands, and become disseminated (*acute cancer*); and 6, in very exceptional instances, the carcinomatous mass has apparently undergone complete atrophy, even, it is said, after ulceration has occurred, and a spontaneous cure has thus been brought about.

Causation.—There is nothing special to remark on this head, beyond what is discussed on p. 118. In particular there is no special prevalence in women who have borne children. Indeed, the reverse—some think prolonged suckling a safeguard; cancer often occurs, too, in breasts with ill-formed, retracted nipples, and in women who have never suckled.

2. *Medullary carcinoma* is much less common in the breast than the scirrhous form, and generally appears at an earlier age. It occurs as a soft, non-encapsuled, compact, white or blood-stained, brain-like mass infiltrating the gland and surrounding tissues. Its growth is much more rapid than the scirrhous variety, and it sooner involves the skin, pectoral muscles, and axillary glands, and rapidly becomes disseminated through internal organs. Early and free removal of the whole breast, and the complete clearing out of all glands from the axilla, is the proper *treatment*.

3. *Colloid carcinoma* of the breast is rare. Its structure is like that of scirrhous or encephaloid cancer, but here and there large epithelial cell-masses have undergone colloid degeneration. It is of slower growth, and less frequently affects the glands than either scirrhous or encephaloid cancer, and has less tendency to recur after removal. The prospective length of life is said to be three or four times that of ordinary scirrhus.

4. *Cystic carcinoma or carcinomatous cysts* are mentioned on p. 1105.

B. **Columnar-celled villous or duct cancer.—Duct carcinoma** occurs as one or more rounded masses lying in the breast tissue not far from the nipple. On section these masses appear as red, encysted and defined tumours (Fig. 544). Microscopically they are columnar-celled carcinomata, and they frequently consist of cysts, which often contain blood, and into which papillary growths, covered by columnar epithelium, sprout. The growths have an alveolar structure, and closely resemble, microscopically, especially when the disease has recurred, ordinary encephaloid carcinoma.

Signs.—The nipple is not, as a rule, retracted, but there is generally a history of a discharge of blood from it, often before a tumour is noticed. In the specimen of which Fig. 544 is a drawing there was very slight retraction of the nipple. The skin is not infiltrated, the axillary glands are not enlarged until late, after a

FIG. 544.—Section of a duct carcinoma of the breast. The tumour has well-defined edges, and is composed of a number of cysts containing growths and broken-down blood. (St. Bartholomew's Hospital Museum, No. 3186 *f*.)

year or more, and secondary deposits are very rare. The tumour is firm and elastic, and may contain one or more cysts. It usually occurs in middle age, is of slow growth, and not accompanied as a rule by pain. The *treatment* consists in amputation of the whole breast. If this is done, no further trouble usually occurs, only if seen late is it necessary to excise the axillary glands.

C. **Squamous-celled carcinoma or epithelioma** grows from the nipple, preceded by eczema of long standing, Paget's disease, irritable fissures, collection of sebaceous material in the pockets of a depressed nipple. It may form an indurated ulcer with everted edges, slowly eating into the breast, or if a papillary growth, with a zone of induration around it. The axillary glands become enlarged and hard. It commonly appears in old people, and may be roughly looked upon as intermediate in regard to malignancy between the foregoing acinous and duct types of cancer.

Indications for removal.—Removal of the breast only is indicated for the benign tumours involving most of the breast, and when the nipple is involved, for the less malignant forms of sarcoma, for

duct cancer and for the earliest appearance of epithelioma in Paget's disease. Excision of the breast and the axillary glands is now considered the proper treatment for all cases of glandular carcinomata, for the more malignant sarcomata or duct cancer and epithelioma when the axillary glands are involved. The limit of operation is the possibility of removing all the disease with a good margin; the most favourable type is the atrophic scirrhus of old people.

Prognosis.—Glandular carcinomata and malignant sarcomata are mostly fatal; the remainder are nearly all cured by operation.

In glandular carcinomata since the adoption of the operation described below, the results show that as many as 50 per cent. of patients may survive the operation for three years, which is longer by two years or more than the duration of life after the diagnosis of patients not operated upon. Moreover when death occurs after operation it is from metastases, not from recurrent disease in the scar. This is especially the case when death does not occur till after three years. But a late recurrence has occasionally taken place in the scar, in one case fifteen years after the operation, in another thirty years after. Both cases then ran the same rapid course as does an early recurrence.

Termination.—Death occurs from exhaustion with secondary growths in the lungs, liver, bones with spontaneous fracture (see p. 363), in the brain, spinal cord, or nerves. When the spinal cord and nerves become affected, the patient suffers excruciating pain, as is also the case when the nerves are involved in multiple metastasis.

The palliative treatment consists in treating the patient with sufficient opium or morphine to relieve pain, and in limiting septic inflammation when fungation occurs. The primary fungating mass may be cut away or burnt down into a cup-shaped cavity with the actual cautery, and this is re-applied when there is any repetition of the fungation. Antiseptic dressings may cause a vascular granulating surface to appear, which may sometimes be covered with skin-grafts. When the arm tends to swell it is carried in a sling or kept elevated on a cushion. If the swelling becomes tense and painful, the arm is soaked in hot water and then massaged towards the trunk; this should prevent the formation of discharging lymphatic vesicles. Should such occur and result in brawny induration there is a continuous flow of lymph, causing an additional source of exhaustion, and the arm in such cases has been amputated at the shoulder joint.

The methods of treatment under trial are by oöphorectomy, by thyroid extract, and by electricity and light (see p. 154).

Oöphorectomy as a palliative measure (pp. 154, 1081).—The beneficial results when they have taken place, have lasted for six to twelve months, exceptionally longer up to three and a half years. Oöphorectomy is not contraindicated by age, for patients long after the

climacteric have obtained benefit; but it is impossible at present to say whether any particular cases will or will not be improved by the operation. The most favourable cases are those in which nodules are recurring in the skin about a scar, or those which are at first sight apparently inoperable, but which after oöphorectomy undergo such contraction of the area involved as to allow of complete removal. Less often, although sometimes, there is improvement in cases where there is recurrence in the axilla or above the clavicle. The existence of metastatic growth may be held to contraindicate oöphorectomy, for no improvement has then followed.

Excision of the breast.—Of late years excision of the breast has been performed in a much more radical way than heretofore. 1. A much larger sacrifice of skin is made, since the skin over the breast contains a network of lymphatics, and if left recurrent growths may quickly form in it. 2. The greater part of the pectoralis major is removed with the breast so as to completely eradicate the lymphatics that ramify in the pectoral fascia. 3. The whole of the lymphatic glands in the axilla are dissected out whether or no any are felt enlarged previous to the operation. 4. The breast with the underlying muscle, the lymphatic vessels and fatty tissue extending to the axilla and the axillary glands are removed in one piece so as to avoid cutting across any cancerous lymphatics, and thus possibly leaving infecting particles.

Operation.—Generally speaking it is safer to cut into the tumour to complete the diagnosis, then filling the small hole with gauze. Surgeons of experience have swept off a breast to find afterwards a cold abscess or simple cyst. If the knife used is put aside, there is no danger such as has been suggested of infecting the wound. The arm is abducted beyond the level of the shoulder, and may be held there extended by an assistant or tied to the leg of the table, or the forearm doubled under the back of the head. A racket-shaped incision is made such as is shown in Fig. 545, or it is modified to suit variation in the position and extent of the main growth. The skin around the incision is raised from the subcutaneous fat, and if, as is often the case, the area removed is extensive, the raising is extended as far as or even beyond the clavicle and sternum, downwards over the lower ribs and backwards to the angle of the scapula. This is done mainly with the fingers or with a blunt instrument, the breast with the pectoral fascia, and a variable amount of the pectoral muscles is now raised towards the axilla. Some surgeons raise both pectorals; others do this only exceptionally, confining themselves generally to the fascia and lower muscular fibres of the pectoralis major, the rest being strongly retracted, so that the pectoralis minor can be stripped in the same way. The tumour is allowed to hang down, and the surgeon turns to the axilla, the insertion of the pectoralis major is divided at the outer angle of the wound, and the axillary vein sought for. The main vein is cleared of glands and fat, without blocking its lumen, up

to where it passes under the clavicle. Meanwhile its branches are seized in clamp forceps and divided beyond the clamp, thus including, not only the vein, but also the corresponding branch of the axillary artery lying immediately behind the vein. To do this the pectorals are drawn forcibly upwards unless they have been already cut away. The surface of the serratus magnus, subscapularis and latissimus dorsi muscles are then cleared, and the subscapular artery and vein, and numerous venous branches about the angle of the scapula are clamped. Many nerves are divided, but the subscapular may be spared if quite uninvolved by disease. No great amount of blood is lost, no more than in former more limited

FIG. 545.—Halsted's incision for complete amputation of the breast. (After Halsted.)

operations; for the dissection along the axillary vein controls most of the vessels before division. Care should be taken near the sternum to cut the perforating arteries long enough to tie. If subclavian glands are felt to be enlarged they can be dissected out by continuing the incision over the subclavian triangle, but it is not necessary to divide the clavicle, the glands being got at by alternately lowering and raising the arm. All bleeding being stopped, the wound is sewn up with a drain in the axillary end or passed through a counter-opening near the angle of the scapula. The incision is brought together, when much skin has been removed, by using interrupted silver wire sutures, especially after thoroughly undermining the skin all round, by which its extensibility is greatly increased without any danger of sloughing. This may be aided by making incisions in several directions more or

less at right angles to the primary incision, by which flaps are the more easily drawn together. Failing this, the raw surface is dressed with gauze for a few days, and then skin-grafted. Immediate skin-grafting may fail from oozing of blood underneath the graft. Tension on sutures is also lessened by drawing skin from some distance towards them by strapping. The wound is dressed and bandaged with the arm partly abducted and extended in an easy position. For bandaging to the side is a cause of great discomfort, and the axilla is deepened so that the wound bags. The tube is removed in a day or two and the stitches between the eighth and tenth days. The armpit requires frequent sponging with one in twenty carbolic acid in fat women who perspire. After healing gentle massage and movement are required.

Operation for recurrent and secondary tumours.—Whenever a recurrent nodule can be removed by cutting through healthy tissue, whether in the scar or deep in the axilla, this should be undertaken. When, however, the cut surfaces are already infiltrated no relief will be afforded. Malignant disease may appear in the opposite breast, sometimes only a short while after the first; less often a long period intervenes. It would seem that such tumours should be regarded as instances not of metastatic but of multiple primary growths. The second breast should be treated by excision whenever the patient is not too exhausted. The metastatic tumours are usually multiple and deep seated, in the liver, lungs, and bones (p. 363), but occasionally a single metastatic growth has appeared, *e.g.*, in the bone of a limb, or in an ovary; and the patient has been relieved and life prolonged by its removal. An arm much enlarged by elephantiasis following venous and lymphatic obstruction from malignant glandular infiltration in the axilla may form a heavy burden, and the patient then be relieved by an amputation at the shoulder joint.

DISEASES OF THE EXTREMITIES.

Excisions and Amputations.

Arthrectomy or erasion of joints consists in scraping or dissecting away the whole of the diseased synovial membrane, after the cavity of the joint has been fully exposed by some such incision as that employed in excisions. It is a useful addition to our methods of treating diseased joints, and appears to be especially indicated for those cases in which the disease is too far advanced to yield to a simpler plan of treatment, but has not as yet, or at least only to a slight extent, involved the cartilages and bones. The extent of the bone lesion, if any, can now be determined in some measure by the *x* rays, since tuberculous deposits, being more transparent than bone, appear as light areas in the skiagram. The incision to expose the

joint is so planned as not to divide important ligaments and tendons. Every pocket as well as the cavities of bursæ communicating with the joint are treated like the joint. A strong antiseptic may be scrubbed into the whole area and then swilled away with water. In the case of tubercle the joint may be dusted with iodoform, after which it is sewn up, no drainage being employed if this can be avoided.

Excision or resection of joints consists in cutting away the articular surfaces of the bones entering into the affected joint, or in removing a portion of bone where osseous ankylosis has taken place. When excision is done for disease it may be said here to prevent repetition that the whole of the diseased synovial membrane should be cut or scraped away, as should also the lining membrane of any sinuses that may be present. Excision may be required for severe injury or for intractable disease of the joint. Space does not permit of a full discussion of the various conditions under which excision should or should not be performed, but it may briefly be stated that it should *not* be undertaken—1, when the disease is acute; 2, when there is much destruction of the bones, or riddling of the soft parts with sinuses; 3, when there is much atrophy of the bones and muscles; 4, when the bones are in a state of osteomyelitis; 5, when the patient is under the age of five or over that of fifty, as, in the former instance, the epiphyses are liable to be removed and the growth arrested in consequence, and in the latter, the powers of repair are usually insufficient to ensure sound healing and a subsequently useful limb; 6, when there is lardaceous disease or signs of phthisis, or other organic mischief; and 7, when the patient's powers of repair are exhausted by long-continued suppuration. Under most of the above circumstances amputation is generally indicated. Excision is usually attended with the best success in the elbow, and here it may be done at a later period of life than that assigned above as the limit. In the shoulder, elbow, and wrist, fibrous ankylosis is aimed at in order to secure a moveable joint; in the hip and knee, firm bony union is sought in the most useful position of the limb, which is that of extension.

Amputations.—The objects that should be kept in view in performing an amputation are:—1, to remove the whole of the injured or diseased part that is beyond the reach of recovery, with as little sacrifice of the healthy tissues as possible; 2, to prevent all unnecessary hæmorrhage; 3, to secure a sufficient covering for the end of the bone; 4, to avoid adhesion of the cicatrix to the bone; 5, to divide the large blood-vessels and nerves transversely, and leave their cut ends in such a part of the stump that they may be little exposed to pressure; and 6, to ensure an efficient drain and aseptic condition of the wound.

Amputations may be performed by the *circular* or by the *flap* method.

upwards by an incision in the long axis of the limb, which is useful for retraction, for ligaturing the main vessels, and for subsequent drainage.

In the *flap method*, double flaps, or a single anterior or posterior flap, are provided for the covering of the bone. The flap or flaps may consist of integuments alone, or of more or less of the muscular and other soft tissues as well. In the former case the flaps are cut (Fig. 547) and reflected, and the muscles and other soft parts are then divided at the level of the base of the flaps in a circular manner down to the bone, which is sawn through a little higher up. By this method most of the advantages of the circular amputation are secured without its disadvantages. It is by far the best method of amputation for all ordinary cases. When, on the other hand, the muscles are included in the flaps, the vessels and nerves are liable to

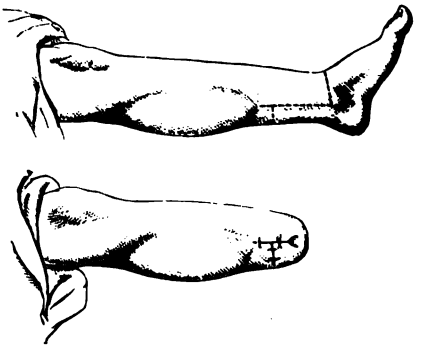


FIG. 548.—Teale's amputation. (Bryant's Surgery.)

be split, or notched, or divided obliquely instead of transversely, whilst the mass of muscle in the flaps tends to prolong the healing of the wound. These muscular flaps may be cut either from without inwards, *i.e.*, from the circumference towards the bone, or from within outwards, *i.e.*, by the method of transfixion. In whichever way the flaps are cut, and whether they consist of integuments only, or of integuments and muscle, they may as regards position be antero-posterior or lateral, or one may be antero-external, and the other postero-internal, or *vice versâ*. As regards length they may be equal, or one may be long, the other short; and as regards breadth they should be half the circumference of the limb. As a rule they should be cut square, but with rounded angles. The following modifications of the flap operation may be briefly mentioned: *Teale's method* for the leg consists in making a long and a short rectangular flap (Fig. 548). The long flap, its length and breadth each equal to half the circumference of the limb, includes all the soft parts down to the bone. The short flap is posterior, or

postero-internal ; its length is one-fourth the anterior, and its breadth equal to half the circumference of the limb ; it also includes all the soft parts down to the bone, and contains the large vessels and nerves. When the operation is completed and the wound closed the stump presents the appearance shown in the lower half of Fig. 548. This method is seldom employed now.

Diseases of the Upper Extremity.

Disease of the sterno-clavicular joint.—The sterno-clavicular joint is commonly attacked in the course of pyæmia. Its other affections—tuberculous disease, rheumatoid arthritis and in ataxia, are all very rare. A fluctuating swelling forms in the course of pyæmia over the joint with only faint inflammatory changes in the skin. *Treatment.*—Incision and drainage ; if there is necrosis, erasion.

Diseases of the clavicle.—*Deformities.*—The clavicle on one or both sides may be absent, causing the shoulder to be rotated forwards and inwards. An acquired deformity is due to rickets, the bone being curved forwards close to the sterno-clavicular joint, so that it is difficult to distinguish from a dislocation.

Inflammation of the clavicle.—Acute osteomyelitis may attack the clavicle, spreading from the sternal end and raising the periosteum, giving rise to a fusiform fluctuating swelling covered by brawny skin. *Treatment.*—Incision the whole length of the bone, and wiping out with an antiseptic. If the bone is dead, it should be at once removed, when the lost clavicle will be quickly replaced by new bone formation.

Tumours of the clavicle—These are gummata, and myeloid and periosteal sarcomata.

A periosteal sarcoma may begin at either end of the bone ; it runs a very rapid course, and the subclavian glands are quickly involved.

Myeloid sarcoma forms a slowly increasing swelling in the centre of the shaft of the bone, which gradually forms a spindle-shaped tumour ; there is no fluctuation, the skin moves freely over it in the early stages, and the subclavian glands are not enlarged. The diagnosis is completed by cutting into the tumour and finding the shell and the maroon colour on section. *Treatment.*—For *myeloid sarcoma* good results have followed excision of the clavicle. The skin is reflected by making an incision along the tumour over the clavicle and cutting through the two ends. Then a careful dissection is required to raise the tumour without injury to the subclavian vein. For a rapidly growing periosteal sarcoma treatment is hopeless. Iodide of potassium may be given to exclude the possibility of its being a gumma.

Diseases of the scapula.—*A congenitally elevated scapula* has sometimes had its upper angle mistaken for an exostosis. The deformity has been attributed to the turning of the arm of the fœtus

behind its back in intra-uterine life. The inferior angle of the scapula is rendered prominent in spinal curvature, paralysis, etc.

The *acromion process* may, instead of uniting, articulate with the spine of the scapula, or perhaps the suture may become disunited as the result of rheumatoid arthritis. Either of these conditions is liable to be mistaken for a fracture.

Acute osteomyelitis, traumatic or pyæmic in origin, may attack the scapula, causing a brawny swelling on the dorsum. More difficult is the diagnosis of subscapular suppuration, which may not be discovered until exploration is carried out. The epiphyses of the coracoid process may become separated. Much or the whole of the bone may necrose, or become infiltrated by tuberculous disease, and the shoulder joint may be involved. *Treatment.*—Early incision and, if necessary, excision of dead bone.

Tumours of the scapula.—The most malignant periosteal sarcomas run a rapid course, spreading to the axilla and chest wall, and causing an enlargement of the subclavian glands.

Myeloid chondro- and osteo-sarcomas are slower in growth, and more favourable for treatment by excision alone, or with amputation of the upper extremity.

Excision of the scapula.—This is required for a tumour which has not extended beyond the bone. With the patient on the opposite side a T-shaped incision is made, one incision down the posterior border of the scapula, to meet another along the spine. Then the flaps are turned back, and the scapula raised along its upper posterior and inner border by clamping vessels derived from the suprascapular and posterior scapular and subscapular arteries. The bone is drawn forwards and away from the chest wall, whilst the muscles—the levator anguli scapulæ and trapezius, the rhomboids, serratus magnus, latissimus dorsi and teres major—are divided. Having raised the bone up to its neck, this is cut across, so as to leave the shoulder joint. The axillary glands or even the subclavian may require removal, but the operation is useless if these glands are widely involved. Hence in a doubtful case a preliminary incision should be made into the axilla to explore. The patient suffers great loss of power for any movements above the level of the shoulder, but no great loss for movements below.

Amputation of the upper extremity.—*Interscapulo-thoracic or Berger's amputation.*—This is required for tumours of the humerus, scapula, or clavicle, especially when the axillary blood-vessels are already involved, but is contraindicated when the tumour is already widely attached to the chest wall. It is hopeless for severe smashes of the shoulder, the result of gunshot wounds. It is safer to begin by ligaturing and dividing the subclavian artery and vein, either through the ordinary incision or after dividing the clavicle or after cutting away the whole bone. From this horizontal incision an oval one extends round the shoulder, being fashioned according

to the position of the tumour and the necessity for skin-flaps. Then the pectorals are divided, next the brachial plexus, then the muscles attached to the scapula. The suprascapular and posterior scapular arteries, if given off on the proximal side of the ligature, are caught in the course of dividing the brachial plexus, and other vessels coming from the spine are clamped as the scapula is cut away. Finally, it may be necessary to remove some enlarged subclavian glands. The wound is sutured and drained from its dependent angle. The shock is severe, but not dangerous, if the vessels are first controlled, but the patient may require some saline infusion (see p. 208).

Diseases of the shoulder joint.—*Acute arthritis* is not common. Suppuration may arise after injury, from acute osteomyelitis (epiphysitis) of the humerus by extension, or in the course of pyæmia.

Tuberculous disease is likewise rare in the shoulder as compared with the hip and knee, but occasionally arises in children in connection with the epiphysis of the humerus, or in connection with the glenoid cavity. It may be distinguished according as the swelling extends forwards, coming to the surface along the biceps tendon, or as it becomes superficial when extending from the glenoid cavity behind and below the joint.

The *chronic affections of the shoulder joint* are rheumatoid arthritis, tending to ankylosis, or locomotor ataxia and syringo-myelia in the course of which the whole head of the bone may disappear, so that the appearances are the same as after excision.

Congenital dislocation of the shoulder joint is due to a malformation of the joint, of the head of the bone and glenoid cavity, and the upper end of the humerus then articulates with the scapula below the spine. But the condition is very much rarer than in the hip.

Ankylosis of the shoulder joint is very apt to occur even after slight injuries, also from rheumatic affections, the liability being due to its relatively exposed condition. The ankylosis occurs readily, owing to the ease with which the scapula moves, so that it is very difficult to keep up passive movement in this joint. Hence excision may be necessary.

Injecting the shoulder joint.—Fluids, iodoform emulsion, etc., may be injected into a tuberculous shoulder joint, by inserting the needle behind at the junction of the spine of the scapula and acromion, or over the coracoid process in front.

Incision and drainage of the shoulder joint.—An incision is made between the deltoid and pectoral muscles, the long tendon of the biceps being retracted outwards, and the joint drained through this wound. By raising the patient, one avoids a counter-opening behind, which might injure the posterior cord of the brachial plexus and the musculo-spiral nerve.

Excision of the shoulder.—Excision of the shoulder is generally practised for gunshot injuries and for myeloid tumours in the head of the humerus. It is also performed for tuberculous and septic

disease of the joint. For simple osseous ankylosis it is rarely needed, as the movements of the scapula on the trunk are so free that they compensate to a great extent for the fixed condition of the joint, and little would be gained by the operation. Excision is also employed for unreduced dislocations of the shoulder, where after free exposure and division of contracted tendons and ligaments, the bone cannot be replaced. *The anterior operation.*—Make an incision (Fig. 549) about four inches long from just outside the coracoid process through the substance of the anterior fibres of the deltoid down to the bone; detach the long tendon of the biceps from its groove, and give it to an assistant to hold aside with blunt hooks. The arm being rotated inwards, divide the teres minor, infraspinatus, and supraspinatus tendons at their insertion into the bone. The arm being next rotated outwards, divide the tendon of the subscapularis, and the head of the bone can be pushed out of the incision. Separate the periosteum as far as is necessary, place a retractor behind the neck of the bone to protect the soft parts, and saw it across. Bring the wound together by suture, place a drain-tube in the lower part, and dress antiseptically. Keep the patient's shoulders raised.

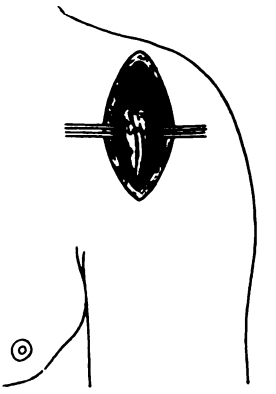


FIG. 549.—Excision of the shoulder. The biceps tendon running in the groove as shown by the interrupted lines must be raised and hooked aside, not divided.

The *posterior operation* after Kocher is indicated for disease of the glenoid cavity. The incision commences at the acromio-clavicular joint, and passes along the upper border of the acromion to its junction with the spine of the scapula; thence it curves downwards to end a finger's breadth above the posterior axillary fold. The trapezius above and the deltoid below being partly separated, the acromion is cut through at its root and turned forwards. The humerus is now rotated outwards, so as to bring the outer lip of the bicipital groove into the incision, and the capsule is divided vertically. The biceps tendon is then drawn forwards, whilst the bone is manipulated, so that either arthrectomy can be done, or the muscles can be separated from the head of the bone which is excised. The glenoid cavity is well exposed, and tuberculous disease can be completely removed. In dividing the acromion the suprascapular nerve passing to the infraspinatus should be avoided, also the circumflex vessels and nerve coming out from under the teres minor. At the end of the operation the acromion is fixed in position by sutures, so that the trapezius and deltoid muscles remain unimpaired.

Amputation at the shoulder joint is required for extensive injuries to the arm, periosteal sarcoma of the humerus, acute spreading gangrene, for elephantiasis, the result of recurring malignant disease of the breast and axilla, also in a patient exhausted by necrosis of the humerus which cannot be relieved by resection of the humerus.

It may be performed either by the oval or by the flap method. In either case the subclavian artery should be compressed, or even ligatured, above the clavicle, or the axillary tied before the amputation is begun. In the *oval method* (*Spence's modification*, Fig. 550), an incision is made from just external to the coracoid vertically downwards, as in excising the joint through the clavicular fibres of the deltoid and pectoralis major, to the humeral attachment of the latter muscle, which is then divided. The incision is next carried with a gentle curve through the lower fibres of the deltoid towards the posterior border of the axilla. A second incision is then made through the skin and fat only, from the point where the straight incision terminated across the inside of the arm to meet the incision at the outer part. The outer flap is next dissected up with the trunk of the posterior circumflex artery, the head freed from its connections, disarticulated, and the remaining soft parts cut through on the axillary aspect, the axillary artery being divided last of all. *The flap method.*—A large flap consisting of integuments and deltoid muscle is usually taken from the outer aspect of the joint, either by transfixion or better by cutting from without inwards. In *transfixion*, the deltoid having been grasped and raised by the surgeon's left hand, the knife should be made to transfix the limb on its upper and outer aspect just below the acromion, and a flap formed with rounded angles about four inches long. The flap is turned back, the head of the bone freed from its connections, and the knife passed behind it, and made to cut its way out towards the axilla, the axillary artery being seized as it is divided. In cutting a flap from *without inwards*, the incision is made from a point just external to the coracoid process and carried in a circular sweep downwards as low as the insertion of the deltoid, and then upwards to the posterior fold of the axilla just behind and below the acromion.

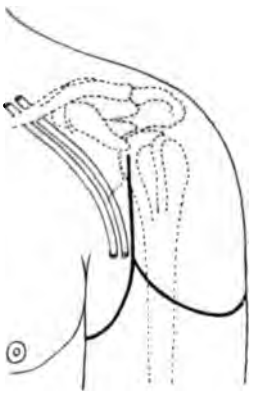


FIG. 550.—Amputation at the shoulder-joint by an oval incision, marked by thick lines; the relation of the artery and vein to the oval flap is also shown.

Diseases of the humerus.—The humerus may be attacked with *septic or tuberculous osteomyelitis* (epiphysitis), which, commencing near the upper or lower end of the diaphysis, may spread

towards the middle of the shaft, causing increasing thickening, or towards the shoulder or elbow-joint. Painful induration or fluctuation points to exploration by incision. The incision to explore the upper third should be a continuation of the anterior incision to explore the shoulder-joint, the biceps tendon being retracted. To explore the lower third an incision is required on the outer side, behind the musculo-spiral and radial nerves. From this incision the diaphysis of the bone can be bored into, and if necessary a groove cut so as to expose the medullary canal. The middle third of the canal can be scraped out from either wound, or the whole shaft when necrosed may be excised. The undestroyed periosteum will re-form the shaft, and in this way the necessity for amputating is avoided.

Tumours of the humerus.—A swelling in the centre of the shaft of the humerus not originated by an injury may be a gumma or periosteal sarcoma. A myeloid sarcoma may arise at either end. A steadily increasing swelling, not checked by anti-syphilitic treatment, should be explored. If a periosteal sarcoma, the arm must be amputated at the shoulder-joint. If a myeloid sarcoma of the upper end, excision may be done, if of the lower end, scraping out the cavity or excision. A metastatic growth may appear in the shaft, see Fig. 145, p. 363.

Amputation through the humerus (Fig. 551 and Fig. 165, p. 415) is required for a severe injury sufficient to cause gangrene, for septic infection and necrosis following a compound fracture or infection of the hand, after failure of erasion and excision of the elbow, and for periosteal sarcoma of the forearm. Gangrene from arterial obstruction is a very rare indication, as compared with the leg. Amputation should be done if possible below the upper third, so that at least a stick or umbrella can be carried in the armpit, or an artificial limb applied. Any method giving enough flap may be chosen, the circular method being most applicable. The essential thing is to shorten the nerves, ulnar, median, musculo-spiral, to avoid ascending neuritis. The humerus below puberty will continue to grow, and cause the stump to become pointed. When this threatens to occur, the upper epiphysis should be destroyed.

Diseases of the elbow joint.—*Suppurative arthritis* may occur from septic injury, pyæmia, or gonorrhœa, and as a complication of tuberculous disease, or by extension of osteomyelitis (epiphysitis) from the humerus, or of suppuration from the olecranon bursa.

Tuberculous disease causes a swelling which may at first be limited to the radial or ulnar portion of the joint, so that there is a cold thickening or fluctuating swelling over the radius without distension of the hollows on either side of the olecranon, or *vice versâ*, or the swelling may be chiefly under the triceps tendon above the joint. Fixation at a right angle on a splint, with alternative fixation by plaster of Paris, the application of mercurial ointment and general

measures having failed, an arthrectomy limited to the affected portion of the joint, followed by long rest in the rectangular position, may be sufficient to arrest the disease.

Ankylosis of the elbow-joint in the rectangular position, with the forearm midway between pronation and supination, is often the best

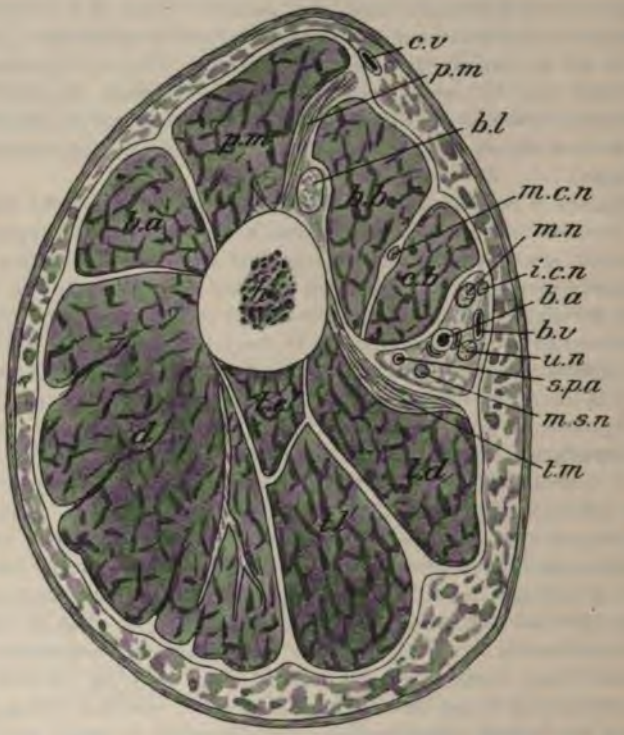


FIG. 551.—Section above the middle of the arm, showing the structures divided in an amputation. After Braune and Esmarch, and Kowalzig. Muscles: *p.m.* Pectoralis major. *b.a.* Brachialis anticus. *d.* Deltoid. *t.e.* External head of triceps. *t.l.* Long head of triceps. *l.d.* Latissimus dorsi. *t.m.* Teres major. *c.b.* Coraco-brachialis. *b.b.* Short head of biceps. *b.l.* Long head of biceps. Vessels: *b.a.* Brachial artery with venæ comites. *s.p.a.* Superior profunda artery. *b.v.* Basilic vein. *c.v.* Cephalic vein. Nerves: *m.n.* Median nerve. *u.n.* Ulnar nerve. *m.s.n.* Musculo-spiral nerve. *i.c.n.* Internal cutaneous nerve. *m.c.n.* Musculo-cutaneous nerve.

thing to aim for, *e.g.*, after suppuration or extensive tuberculous disease, lest movement cause a relapse. The arm can then be used for most purposes, *e.g.*, carrying weights, and the loss of supination and pronation is compensated by abduction of the shoulder. Ankylosis in a faulty position, the elbow being more or less completely extended, renders the arm useless and favours venous

congestion. This occurs from neglected injuries and inflammations about the joint, also in slowly progressive changes, as arthritis deformans. *Fibrous union* may be treated by cutting into the joint by a horizontal incision commencing from the outer edge of the olecranon round to the edge of the biceps muscle in front, so cutting into the radio-humeral joint and separating the bones; this, with a partial tenotomy of the contracted triceps, may suffice to bring the arm up to a right angle, where it is fixed. For *bony union*, and when free movement is to be obtained, an excision is required.

Flail elbow results from spinal paralysis, also from excessive removal of the ends of the bone. In the latter case, as the muscles providing the long tendons for the hand get a fresh attachment to the forearm, the finer movements of the hand and wrist are regained when the elbow is fixed in an apparatus. In spinal paralysis, some shoulder and hand movements remaining, it has been proposed to artificially ankylose the elbow-joint (*Arthrodesis*).

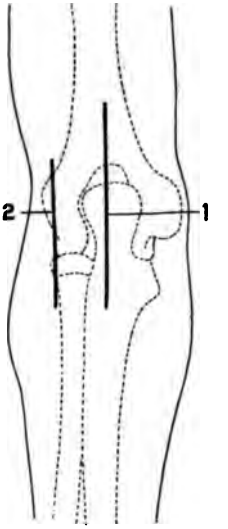


FIG. 552.—Lines of incision for arthrectomy of the elbow. 1. Posterior median incision. 2. Posterior radial incision.

Injections may be inserted over the head of the radius, or on either side of the olecranon.

An *incision* for the escape of pus may be made externally behind the radio-humeral articulation, or internally behind the trochlea, avoiding the ulnar nerve. The small opening so obtained may suffice for the escape of pus.

Arthrectomy of the elbow. — Partial arthrectomy, with limited scraping or gouging away of diseased bone, may be done through a longitudinal incision (Fig. 552) over the radio-humeral articulation, along the inner border of the supinator longus. A posterior longitudinal incision, splitting the triceps down to the olecranon, allows of the evacuation of a tuberculous collection formed beneath the triceps by the bulging of the slack posterior capsule. The extension of this incision, through the skin only, over the tip of the olecranon, permits of the olecranon being sawn through at its junction with the ulna, and so, on complete flexion, a view of the joint is obtained without the division of any other important ligament or structure. The olecranon process, which has remained attached to the triceps, is afterwards brought down and fixed in position by wire or pegs.

Excision of the elbow.—The elbow may be excised for chronic disease of the joint, gunshot or other injury, myeloid sarcoma of the

ends of the bones, and osseous ankylosis. Some surgeons only recommend excision for ankylosis when the elbow is fixed in a faulty position. The operation, however, is attended with so little risk, the advantages of a moveable elbow are so great, and the results so good, that others unhesitatingly excise the joint in whatever position it may be fixed. The *operation* may be performed in several ways; but that by

FIG. 553.—Section through the elbow joint to show the relation of structures in connection with the operation of excision. After Braune and Esmarch, and Kowalzig. Bones, Ligaments and Synovial Membrane: *h.* Humerus. *e.e*, *i.e.* external and internal condyle. *o.* Olecranon. *e.j.*, *e.j.* Elbow joint. *o.b.* Olecranon bursa. *e.l.l.*, *i.l.l.* External and internal lateral ligament. Muscles: *s.l.* supinator longus. *e.c.r.* Extensor carpi radialis. *a.n.* Anconeus. *t.* Triceps. *f.c.r.* Flexor carpi radialis. *p.r.t.* pronator radii teres. *b.a.* Brachialis anticus. *b.* Biceps. Vessels: *b.a.* Brachial artery with venæ comites. *i.p.a.* Inferior profunda artery. *m.c.v.* Median cephalic vein. *m.b.v.* Median basilic vein. *a.u.v.* anterior ulnar vein. *p.u.v.* Posterior ulnar vein. Nerves: *m.n.* Median nerve. *u.n.* Ulnar nerve. *r.n.* Radial nerve. *p.i.n.* Posterior interosseous nerve. *m.b.m.s.n.* Muscular branch of the musculo-spiral nerve. *i.c.n.* Internal cutaneous nerve.

the single vertical incision (*Langenbeck's*) is undoubtedly the best and the one most frequently practised. Make a vertical incision about five inches long over the back of the joint (Fig. 552, 1), beginning about two and a half inches above the olecranon; and carry it over this process and down the ridge on the ulna for the same distance. The incision should extend in its whole length down to the bones. Cut into the joint above the olecranon and clear the condyles of the soft tissues by keeping the edge of the knife in contact with the bone, taking special care not to injure the ulnar nerve behind the internal

condyle or beyond under the extensor carpi ulnaris (Fig. 553). Divide the lateral ligaments, and whilst the assistant strongly flexes the joint to force the bones out of the wound, free them from their remaining connections, and saw off the olecranon, the head of the radius, and the lower end of the humerus, steadying the parts with the lion forceps. If possible, the coronoid process of the ulna and the tubercle of the radius should not be removed, and the shaft of the humerus not encroached upon. Preserve the connection of the anconeus with the triceps, as better extension of the arm will be thus obtained. Unite the wound by sutures, after inserting a drain, and place the limb on a splint in a flexed position. Callender's splint is one of the best for the purpose, as it permits of passive motion not only in the direction of flexion and extension, but also in that of pronation and supination, and without removing the arm from the splint. It also allows of the limb being slung by pulleys from the ceiling, which is much more comfortable for the patient than placing it on a pillow. Passive movements of the fingers and wrist should be begun in a day or two, and pronation and supination at the end of the first week, followed by flexion and extension as soon as the wound has healed, the aim of the surgeon being to obtain a moveable joint.

Diseases of the radius and ulna.—*Deformities.*—A congenitally arrested development of one or other of the bones causes a deformity with a deviation of the hand. In the so-called club-hand the thumb, the radial side of the carpus, and the radius itself, are more or less arrested in development, and the unopposed growth of the ulna pushes the hand over to the radial side. The destruction of an epiphysial cartilage by injury or suppuration leads to an arrest of growth. In the case of the epiphysis of the radius, its lower or upper one, the ulna continues to grow, and has to bend like a bow, being fixed at either end to the radius, whilst the hand becomes deviated to the radial side. An improvement in usefulness may sometimes be obtained, *e.g.*, by resection of the ulna in arrested development of the radius. Paralysis in the distribution of the musculo-spiral allows of the unopposed action of the pronators. Tubby has in such paralyses strengthened supination and obviated the over-pronation by detaching the insertion of the pronator radii teres and carrying the tendon *behind* the radius, where it is fixed by sutures through holes drilled in the bone. This turns the muscle into a supinator, now opposing the pronator quadratus.

The bones of the forearm are subject to *septic and tuberculous osteomyelitis*, most commonly commencing near the lower end of the radius or ulna. This may require local or total excision of the bone, which, being done early, the bone is restored and the deformity above mentioned avoided.

Syphilitic periostitis and gummata attack the middle of the shaft, especially the superficial portion of the ulna.

Tumours of the radius and ulna.—A myeloid sarcoma beginning in the centre of the bone occurs more frequently near the lower end. Periosteal sarcomata arise especially in the middle of the shaft, *e.g.*, following within a year of an injury. In the latter case a rapidly growing tumour may be treated for syphilis, and not being arrested, should be explored, and periosteal sarcoma being proved, the arm

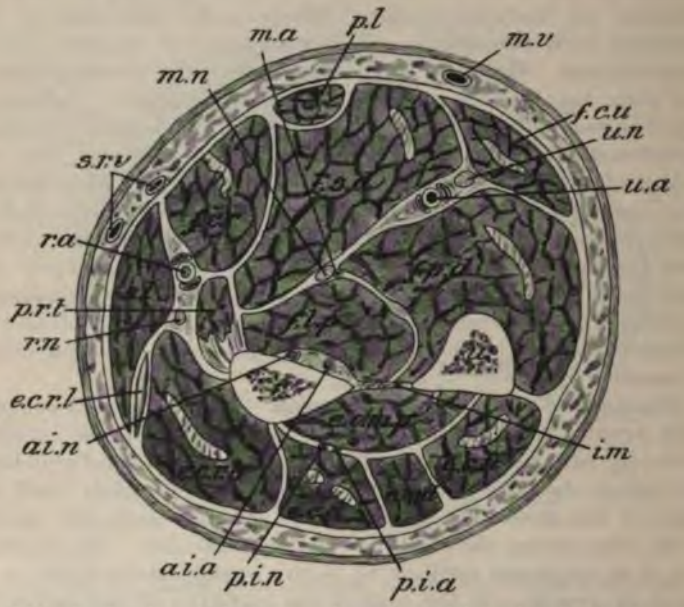


FIG. 554.—Section through the forearm above the middle to show the structures cut through at an amputation. After Braune and Esmarch, and Kowalzig. *r.* Radius. *u.* Ulna. *i.m.* Interosseous membrane. Muscles: *s.l.* Supinator longus. *p.r.t.* Pronator radii teres. *e.c.r.l.* Extensor carpi radialis longior. *e.c.r.b.* Extensor carpi radialis brevior. *e.c.d.* Extensor communis digitorum. *e.o.m.p.* Extensor ossis metacarpi pollicis. *e.m.d.* Extensor minimi digiti. *e.c.u.* extensor carpi ulnaris. *f.l.p.* Flexor longus pollicis. *f.p.d.* Flexor profundus digitorum. *f.s.d.* Flexor sublimis digitorum. *f.c.u.* Flexor carpi ulnaris. *p.l.* Palmaris longus. *f.c.r.* Flexor carpi radialis. Vessels: *r.a.* Radial artery and venæ comites. *u.a.* Ulnar artery. *m.a.* Median artery. *a.i.a.* Anterior interosseous artery. *p.i.a.* Posterior interosseous artery. *s.r.v.* Superficial radial vein. *m.v.* Median vein. Nerves: *m.n.* Median nerve. *u.n.* Ulnar nerve. *a.i.n.* Anterior interosseous nerve. *p.i.n.* Posterior interosseous nerve. *r.n.* Radial nerve.

should be amputated above the elbow and the axillary glands cleared out if already involved. A slow-growing enlargement near the end should be explored, the diagnosis resting between myeloid sarcoma and chronic central osteomyelitis or quiet necrosis with increase of periosteal bone. A myeloid sarcoma may be completely scraped away from within its shell, which is crushed inwards, and the remaining cavity filled with gauze. If it has extended beyond, excision of both bones, the ulna in addition to the radius although

it is uninvolved, the ulna only if the radius is sound, results in definite healing, leaving a useful hand. Excision should be done through lateral incisions, avoiding arteries, nerves, and tendons. If both bones are divided the cut ends are sutured together.

Incisions of the forearm are made longitudinally, avoiding (see Fig. 237, p. 565, and Fig. 554) nerves and arteries, splitting muscles, and retracting tendons. The best incisions are median, anterior or posterior; or lateral, radial or ulnar.

Amputation of the forearm is required for primary injury, but only when it is hopeless to attempt to save the limb. Skin stripped off or destroyed by burning may be replaced by skin grafting, the nerves, muscles, and bones being cleaned and sutured. Amputation is also required for septic infection of the hand and wrist when a further extension threatens life, and especially when the progress already made has caused much suppuration in the wrist and carpal joint with necrosis, so as to render healing hopeless. Yet the stiffest hand is better than an artificial one. Amputation (see Fig. 554) through the forearm may be done by antero-posterior flaps, the muscles divided in a circle and retracted, and the bones divided higher up, having first passed a pointed knife through the interosseous membrane. The arteries are tied, the nerves well shortened, and then the tendons stitched to the bone or flexor to extensor tendons to prevent retraction.

Diseases of the wrist joint.—Septic arthritis extends from the palm to the wrist. It may also be of pyæmic origin, especially gonorrhœal.

Tuberculous disease often begins insidiously with stiffness and aching in the wrist and fingers, while projections appear and distensions of the tendon sheaths, tuberculous ganglions or tenosynovitis. This is treated by rest and mercurial inunction. The wrist may be fixed in a plaster case like a mitten, leaving the thumb and fingers free. If the disease progresses, partial arthrectomy or excision is required.

Injections into the wrist joint should be done immediately below the radial or ulnar styloid process.

Partial arthrectomy may be limited to an incision over a ganglion or distended tendon sheath.

Excision of the wrist has for its object the complete removal of the disease, whilst retaining especially unimpaired the opponens movements of the thumb and flexion of the fingers at the metacarpophalangeal and interphalangeal joints. All the bones of the carpus except the trapezium, the cartilaginous bases of the metacarpal bones and of the radius and ulna, including the lower radio-ulnar articulation, can be removed without injuring the radial and ulnar arteries, the median and ulnar nerves, or the numerous tendons (Fig. 237, p. 565). The incisions employed are (Fig. 555):—(1) A *long posterior median incision* over the lower third of the forearm, the carpus and metacarpus. (2) A *long ulnar*

incision along the ulnar border of the forearm and hand down to the base of the fifth metacarpal. (3) *Lister's incision*, one ulnar not so long as the preceding, combined with a posterior radial incision in the line of the extensor secundi internodii pollicis tendon in the forearm, then along the radial side of the second metacarpal for half its extent. In all the procedure is the same, the raising of tendons and nerves by the raspatory and retracting, whilst the bone is removed piecemeal, leaving the trapezium and the first metacarpal which as a matter of fact escape the tuberculous process. If the posterior median incision is used, the wrist is forcibly flexed until, by partial removal of the carpus, the ends of the bone can be thrust out through the wound; if the ulnar incision, then the hand is forcibly bent towards the radius. Lister's incision combines both the foregoing. The posterior median incision has the advantage of not weakening the ulnar side, so preventing a tendency afterwards to radial deviation of the hand, and avoids a scar near the thumb tendons. The hand is placed on an anterior splint to which a rounded piece of cork has been fixed, upon which the hollow of the palm rests, causing the hand to be partly extended upon the forearm and the fingers to be flexed. As soon as the wound has healed plaster in the shape of a mitten is applied. The fingers and the thumb are moved and massaged, commencing a day or two after the operation. Active opposing and circumduction movements of the thumb and flexion and extension of the fingers are encouraged whilst ankylosis between the forearm and metacarpus is aimed for. Thus the power of writing and grasping light objects is preserved.

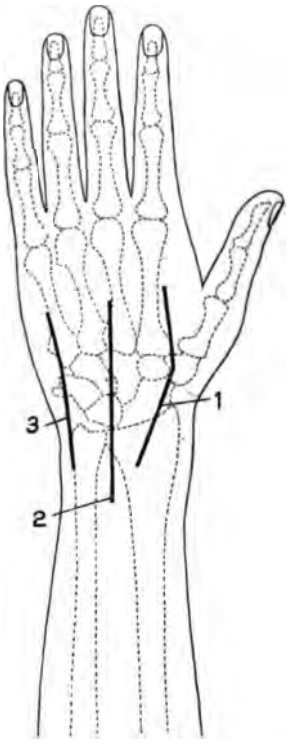


FIG. 555.—Dorsal incisions for excision of the wrist. 1. Angular incision. After Lister. 2. Median incision. 3. Ulnar incision.

Amputation of the wrist is very seldom indicated. Injuries of the hand, such as extensive smashes, may be treated by conservative measures, if septic inflammation is prevented by thorough cleaning at first. A stiff hand, even where the thumb can only oppose one or two fingers or the fingers merely hook an object, will

be more useful for writing and holding light objects than any artificial hand. Amputation may be done by antero-posterior flaps, or a small flap may be taken from any part least injured, for example the thenar or hypothenar eminence. The points of the styloid processes may be sawn off. The radio-ulnar articulation should be preserved intact to permit of pronation and supination. Tendons should be sutured, to prevent retraction, either to the periosteum or flexors to extensors. The median and ulnar nerves must be shortened. If the radio-ulnar articulation is affected, it is better to cut the bones through higher up.

Septic infection of the hand and fingers.—Two factors are always in evidence in serious cases, the virulence of the organisms and the lack of resistance of the patients. The virulence of the organisms appears in the infections received in the course of medical work, during surgical operations on septic cases, especially those infected by streptococci in erysipelas, etc., in post-mortem examinations of patients dead of purulent peritonitis, puerperal fever, scarlet fever and diphtheria with septic complications. Decomposing animal and vegetable material yields virulent gas-forming organisms entering through scratches or on splinters or thorns. Specific disease may be inoculated on the hand or fingers, syphilis during examinations and operations, anthrax or glanders in skinning or destroying animals dead of the disease.

(1) *Whitlow or paronychia*, as the superficial septic infections of the fingers are called, are prevented by going for a holiday and leaving surgical work when fingers tend to become sore or small pustules form; by habitually attending to the hands, keeping them clean, trimming the nails, snipping off tags of skin. When about to touch septic material the nails may be filled with soap or antiseptic wax, or rubber gloves put on. It is a bad practice ever to use the finger-nail as a curette for scraping. A puncture should be well squeezed until blood flows, fomented with hot carbolic or sublimate lotion, dried and covered with collodion or a rubber finger-stall. Inflammation starts at the deepest point of a puncture, under or beside the nail or in the pulp of the ungual phalanx. There is pain, throbbing, with redness, swelling, heat, elevation of temperature, and malaise. A dangerous infection shows signs of inflammation within an hour or two of the inoculation and the temperature rapidly rises to 102° F. or above. *Treatment.*—The nail is notched backwards until pus is reached or a splinter or thorn can be fairly seized with forceps so that it can be drawn out without breaking up. Epidermis from the side of the nail or on the finger in shaved off or cut away. If subcutaneous the patient should be given nitrous oxide gas without delay, the site of infection exposed, well scraped out and scrubbed out with pure carbolic acid. A hot boric acid fomentation is at once applied, on which tincture of opium may be dropped, or morphine is given hypodermically.

or ganglion near one end of a phalanx, in the neighbourhood of an epiphysis, but especially as a central osteomyelitis in the middle of the shaft of a phalanx, which slowly becomes spindle-shaped from eccentric absorption, with formation of periosteal new bone. The shell is perforated, and the disease bursts externally, after which caries progresses. *Treatment.*—Scraping, excision, or even amputation of the finger to prevent extension to the hand.

Tuberculous warts develop in some persons who handle anatomical and post-mortem material. There is little tendency to ulceration. Cessation of the irritation, fresh air, and mercury ointment may cause them to disappear; if not, excision is required.

Tuberculous tenosynovitis.—*Simple and Compound Ganglion* (see p. 370).

Rheumatic and gouty nodules (see pp. 346, 350).

Gangrene of the fingers (see *Gangrene*, p. 44) results from injury, frostbite, Raynaud's disease, from carbolic acid fomentation, exposure to *x* rays.

Chancre of finger (see p. 77).

Infective warts appear on the hands of children, especially when in ill-health or neglected, and are easily spread by contact with blood from the warts. They tend to disappear spontaneously, aided by improved hygiene, indeed, are often supposed to be charmed away. If detached, the bleeding point should be touched with caustic or a red-hot needle, which will cure.

Tumours.—Multiple small *aneurysms* have been seen on the small vessels of the fingers. Multiple small *lipomata* are congenital in origin; a *diffuse lipoma*, spreading along a tendon sheath, and forming a soft, elongated, doughy tumour, has been traced to a blow. Multiple *enchondromata* commence in the centre of the shaft of the phalanges and metacarpals (see p. 357). Multiple *fibromata* (they are not neuromata) grow in connection with the nerves or their end-twigs in the subcutaneous tissue. They are painful when pressed on, and the skin over them tends to ulcerate. Also the ungual phalanges may present signs of nerve paralysis.

An *epithelial implantation cyst* arises beneath the scar of a cut or puncture from a bit of epidermis carried in, which forms a cyst containing epithelial débris, without hair or sebaceous glands in the wall as in the case of a dermoid cyst.

Fibrosarcoma may arise after an injury, also myeloid sarcoma from the centre of a bone.

Melanotic sarcoma has commenced as a blackish foul ulcer on the the finger, followed by enlargement of the axillary glands from infiltration.

Epithelioma arises in a wart, chapped hand, or sore from working with soot, gas tar products, etc., and runs a relatively benign course. But any chronic indurated everted ulcer in an old person should

be at once excised, and the lost skin replaced by grafting, lest amputation become necessary.

Deformities of the hands.—*Dupuytren's contraction* of the palmar fascia results from a chronic inflammation. It is more common in men than in women, generally begins in middle life, and frequently affects both hands. It has been attributed to heredity, gout and rheumatism, and to habits or occupations necessitating pressure in the palm, or flexion of the fingers, or to inoculation of the subcutaneous connective tissue with a specific germ by a scratch of the palm by the finger-nail. The affection consists in a shortening of the prolongations of the fascia from the palm on to the sheath of the flexor tendons. The tendons themselves are not affected. The contraction generally begins in the fascia of the little or ring finger as a small rounded fibrous nodule, and later may affect that of the middle finger, and at times the forefinger and also the thumb. The affected fingers (Fig. 556) are drawn by tense bands towards the palm, and in severe cases may become fixed in contact with it. The skin being adherent to the fascia, is thrown thereby into transverse puckers. The affection may be distinguished from a contracted tendon by the latter forming a tight cord, which can be traced under the annular ligament, and by the skin in the case of the contracted tendon being free. In contraction of the fascia, moreover, two tense bands can generally be traced to the sides of the finger, whereas a contracted tendon is centrally placed. The last phalanx is not involved in the contraction of the fascia, but is often flexed in a contracted tendon. *Treatment.*—The progress of the contraction is checked by applying a splint at night to keep the fingers fully extended, by gentle passive movements, massage, mercurial inunction, and general treatment. When the finger is already drawn down, the contracted fascia may be excised by making a V-shaped incision pointing upwards through the skin, which becomes a triangular wound as the finger is straightened. Through it the fascia, with its prolongation forwards to the sides of the phalanges laterally, is carefully dissected out. Then the triangular wound is sutured by drawing the edges together in the shape of a Y. There is less tendency to relapse after this than after the older method of subcutaneous division.

Fig. 556.—Dupuytren's contraction of the palmar fascia. (From a cast in St. Bartholomew's Hospital Museum.)

Subcutaneous division is done by making several punctures in the palm near the web and at the side of the proximal phalanx opposite the

puckers in the skin, not in the creases, so that the punctures do not gape when the fascia is stretched. In the latter case in particular, a splint must be worn at night for months to prevent recontraction.

Deformities of the fingers.—*Webbed fingers.*—Two or more of the fingers may be united by a fold prolonged forwards between them up to the nail, the web consisting of a double layer of skin with a little intermediate connective tissue. *Treatment.*—After careful cleaning the web is divided down the middle line, and the edges on each side united by a fine suture, when, if there is sufficient skin, healing occurs by first intention. If it does not, epidermal grafts should be applied. An older method was to perforate the web at its base for a ring of stout silver wire, which was worn until, like an earring, the perforation became lined with skin, when the fold was divided. By this means reunion beginning at the upper angle was prevented. A plastic operation has been proposed, by which the web is divided into a dorsal flap attached to one finger, which covers its raw surface, and a palmar flap for the other. But there is much tendency to scarring and contraction, and if the fingers are closely joined or partly fused, they are better left alone, lest being divided both have to be cut off.

A finger may be bifid, show excess of length, or remain unduly short or suppressed. The thumb may be absent in club-hand (see p. 1127), or be replaced by three ulnar fingers, with a partial ulna on the radial side of the radius, an incomplete doubling of the hand.

Supernumerary fingers.—Six fingers and toes may occur as a spontaneous variation, and be inherited for a generation or so by some members, and then tend to die out.

A supernumerary thumb or little finger is a useless appendage, but as it is in communication with the tendon sheath and joint of the digit to which it is attached, special antiseptic precautions must be taken in removing it.

Contracted finger subsequent to an injury may be rendered more useful by lengthening its tendon.

Loose finger.—The division of a tendon may result in the loss of power in a finger which still remains freely moveable. The sheath of the tendon is exposed, and the ends brought together, or, if need be, a splice from an adjacent tendon, the tendon of an animal, or strands of kangaroo tendon, are used to join the ends.

Snapping or trigger or clasp-knife finger.—The finger on being flexed suddenly closes into the palm and cannot be extended except by aid of the other hand. By some surgeons it is considered due to irregularities in the joint surface, and some recommend its removal.

Amputation of the finger or thumb.—The knife shown in Fig. 557 may be used.

The *thumb* at the carpo-metacarpal joint may be amputated by transfixion or by an oval incision. In the *transfixion* method the

point of the knife in operating on the right side is entered at the web of skin between the first and second metacarpal bones, and made to emerge on the palmar aspect of the carpo-metacarpal joint. A palmar flap is then cut from the tissues forming the ball of the thumb, and the knife drawn obliquely across the back of the thumb from one extremity of the flap to the other. In operating on the left side, the oblique incision across the back of the thumb is first made, then the point of the knife is thrust down through the web and made to transfix as on the right side. In the *oval or circular* method, the knife is entered midway between the base of the metacarpal bone and the styloid process of the radius, and the incision carried obliquely along the dorsum of the metacarpal bone to the

FIG. 557.—Finger knife.

first phalanx, and then round the palmar surface and back again to the former incision, keeping close to the bone.

The *fingers* may be amputated by double flaps or by a long anterior flap. In amputating a finger it should be remembered that the joint is in front of the knuckle. If the whole finger requires removal, the head of the metacarpal bone should be nipped off with bone forceps, unless breadth and strength of hand is the chief desideratum, when it should be left, supposing there is enough flap.

DISEASES OF THE LOWER EXTREMITY.

Disease of the pelvic bones.—*Septic osteomyelitis* is usually secondary. The symphysis pubis and the sacro-iliac synchondrosis are involved in septic infection such as puerperal fever; the rami of the pubes and ischium may undergo necrosis owing to extravasation from the bladder, or the infection may spread from the hip-joint. *Treatment.*—Free exposure, removal of dead bone, application of antiseptics, and gauze dressings.

Tuberculous osteomyelitis may commence in the sacro-iliac synchondrosis, or on the crest of the ilium in connection with the line of the epiphysis; or it may be secondary by extension from the hip-joint. *Treatment* by removal is apt to fail owing to the wide infiltration of the bone, and the patient ultimately dies of exhaustion and amyloid disease.

Tuberculous disease of the sacro-iliac synchondrosis usually occurs in young adults, occasionally in children. There is pain, swelling, and later redness over the joint, followed by the formation of abscesses which may open posteriorly or through the sciatic notch, above Poupart's ligament, in the ischio-rectal fossa, or into the rectum. The pain, which is increased on exertion or by putting

the abdominal muscles into action, as in coughing or sneezing, may be reflected along the sciatic nerve, simulating sciatica, or along the obturator nerve to the hip or knee, and may then be increased on moving the hip. The thigh, moreover, in consequence of the irritation of the psoas, may be slightly flexed. The disease may thus have to be diagnosed from hip disease and spinal caries. On fixing the pelvis, however, the hip and spine move freely and without pain, but pain is felt on making pressure inwards or outwards on the iliac crests or over the sacro-iliac joint. When sinuses have formed carious bone may sometimes be detected on probing. The *prognosis* is unfavourable unless sepsis is prevented. The *treatment* consists in keeping the parts at absolute rest by fixing the pelvis and thigh in a moulded leather splint reaching to the knee. If this fails the joint should be exposed, before abscesses or sinuses have formed, by cutting off the posterior angle of the crest of the ilium and chiselling away the adjacent bone. The diseased tissue should then be scraped and gouged away, and the wound plugged with iodoform gauze and dressed antiseptically. After sinuses have formed, with extension to the ilium and sacrum, the results are unsatisfactory, as if sepsis has occurred it is difficult to arrest it.

Tumours of the pelvic bones are *benign*, exostoses or hydatid cysts, or *malignant*, central myeloid sarcomas, chondro-sarcomas, and rapidly-growing periosteal sarcomas. Removal, if they can be reached, is likely to succeed only in the case of the first three named; in the latter case the bone is too widely infiltrated.

Diseases of the buttock.—*Enlargement* of the buttock may be due to backward displacements of the hip, whether traumatic, congenital, or secondary to disease, and to swellings. *Flattening* of the buttock follows displacements of the hip forwards, and wasting of the glutei muscles is the result of hip-joint disease.

Swellings of the buttock may be:

(1) *Inflammatory.* (*a*) An ischial bursa (see p. 375); (*b*) a gluteal abscess arising *in situ*, from a septic wound, or following suppuration in an ischial bursa, or due to diseases of the pelvic bones (see above), or to extension from the hip-joint (see below), or from an ischio rectal abscess (p. 943). A pelvic abscess (p. 1071), or a psoas abscess (p. 1186), may track into the buttock through the sciatic notch.

(2) A *gluteal hernia* (see p. 931).

(3) A *gluteal aneurysm* (see p. 402).

(4) A *new growth*, (*a*) a lipoma, encapsuled, or diffuse in a woman tending to obesity; (*b*) a sarcoma, myeloid or periosteal, growing from the pelvic bones (see above).

Disease of the Hip-joint.

Acute suppurative arthritis is septic in origin, due to staphylococci, which start suppuration in the neck of the femur, on the shaft side

of the epiphysial line, but owing to this line being within the joint the pus generally bursts into the joint. Less frequently it remains shut off from the joint by the synovial membrane. The hip disease as described below then runs a very acute course. The head of the bone beyond the epiphysial line may become necrosed, the pelvis be perforated through the acetabulum, and an abscess collect within the pelvis and burst into the bladder. Or the pus may extend along the inter-muscular planes of the thigh, septicæmia and pyæmia may supervene, and the patient die. Septic inflammation exceptionally attacks the epiphysis of the great trochanter. Thus in two cases, both in girls who had fallen on the great trochanter, but got up and were able to walk well immediately after the accident, acute septic inflammation was followed by necrosis of the epiphysis, pyæmia, and death (Astley Cooper).

Treatment.—A very early incision, the removal of the head and neck if necrosed, and the application of a strong antiseptic is required. When extension occurs before this is done the prognosis is bad.

Tuberculous disease of the hip.—The disease may begin in the synovial membrane or in the bones. In the latter case the tuberculous process may at first be confined to the neck below the epiphysial line and end in a circumscribed abscess in the neck or great trochanter, which only later bursts through the lower part of the neck into the synovial cavity. Or, the tuberculous process may lead to the destruction of the epiphysial cartilage and the carious head be found loose in the joint. At times the acetabulum becomes greatly enlarged by the presence of the head causing absorption of its posterior margin, whilst a new rim of bone is formed from the periosteum a little higher. The head with the acetabulum is thus carried towards the dorsum ilii (*travelling acetabulum*).

Signs.—In the early stages of the disease, which is most often met with in childhood, there is slight lameness, some limitation in the range of movement of the joint, generally pain, and often quite early some atrophy and wasting of the muscles. The pain, though at times severe, is more frequently slight, and may only cause starting pains at night or be elicited on making certain movements of the joint. It may be felt in the hip, or, as is commonly the case, be referred to the knee or to other parts supplied by the obturator nerve, as the inner side of the thigh. At times it may be felt in both hip and knee simultaneously. The joint is slightly stiff, not only on flexion and extension, but also on rotation and on abduction and adduction, especially in the semi-flexed position. There is often some fulness about the front of the joint, flattening of the nates, loss of the gluteal fold, and perhaps tenderness on pressure. The joint becomes at first slightly flexed, everted, and abducted, *i.e.*, it assumes the position in which the capacity of the synovial cavity is greatest and the ligaments of the inflamed joint are most

relaxed—the position of greatest ease. When fluid is injected into the hip-joint of the normal cadaver, the limb takes this position as the synovial cavity becomes distended. In order to bring the flexed and abducted limb to the ground, the pelvis is depressed by the patient on the affected side, and hence the limb appears when placed parallel to its fellow slightly lengthened

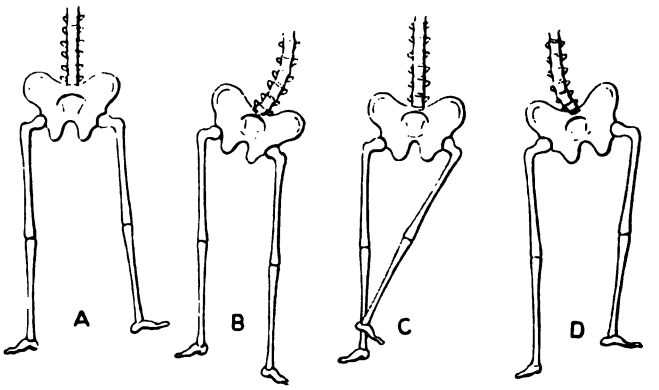


FIG. 558.—To show the effects of abduction (A), and adduction (C) in causing apparent lengthening (B), and apparent shortening (D) of the limb in hip-joint disease, when the affected limb is placed parallel to the opposite limb.

FIG. 559.—To show the lordosis of the lumbar spine when the limb is placed in the straight position. P. Psoas muscle.

FIG. 560.—To show effect of flexing the limb on the lumbar lordotic curve. P. Psoas muscle.

(Fig. 558, A and B). Later, the joint becomes further flexed; but inverted instead of everted, and adducted instead of abducted, a change of position which has been variously attributed to erosion of the posterior part of the acetabulum, a yielding of the ligaments, or exhaustion of the external rotator and abductor muscles. To overcome this position of adduction in which the limb is useless, the pelvis is raised on the affected side, so that the limb, if brought parallel to the other, now appears slightly shortened (Fig. 558, C and D) in place of being lengthened. Whilst the

position of abduction and adduction is overcome by depressing or raising the pelvis respectively on the affected side, *i.e.*, by laterally bending the lumbar spine, flexion is overcome by rolling the pelvis forward, *i.e.*, by increasing the normal lumbar curve. Hence when the patient is laid on his back and the limbs are brought down parallel to each other, there is always considerable lordosis of the lumbar spine (Fig. 559), which, however, disappears on flexing the affected limb to the angle at which it is held flexed by the contracted muscles (Fig. 560). The flexion may also be shown by flexing fully the sound limb on the abdomen, when the lordosis will disappear, and the limb on the diseased side will rise up from the couch and assume the angle of flexion at which it is fixed. Later in the disease real shortening ensues, owing to the destruction of the joint and the dislocation of the head of the bone on to the dorsum of the ilium, which takes place quietly without requiring force. The pus, when an abscess has formed, usually makes its way towards the surface between the tensor vaginæ femoris and sartorius, and a fluctuating swelling is produced in this situation a little below and external to the joint. It may either escape through the front of the capsule or through the posterior part and then track along the course of the external rotators to the front. In some cases the abscess opens behind in the gluteal region or at the inner side of the femoral vessels. Finally sinuses may form and the disease progress in the way described under *Tuberculous Arthritis*. Not infrequently the acetabulum may become perforated and the suppuration extend into the pelvis, a fact that may be discovered by an examination per rectum. Pointing may then occur above Poupart's ligament, or the pus may make its way into the rectum, ischio-rectal fossa, or through the sciatic notch.

Diagnosis.—Hip disease, like other joint affections, may be simulated in *neuro-mimetic* subjects (see p. 334), and reflex pain in the joint is not uncommon in *phimosis*. In *psoas abscess*, in which the joint may be held in a position of slight flexion, abduction and eversion, the freedom of movement in the joint, the absence of pain and the presence of a fluctuating swelling in the course of the psoas and of spinal deformity, should distinguish it from hip disease. An *abscess* in the neck of the femur may closely simulate hip disease, but the non-impairment of the movements of the joint on careful manipulation will show that the joint is not involved. The diagnosis from *sacro-iliac* disease is given on p. 1139.

Treatment.—As regards constitutional treatment nothing need be added to what was said on pp. 338—342. The indications for the local treatment are similar to those for tuberculous disease of the joints generally, but require certain modifications in the methods of carrying them out. Thus, if the symptoms are acute the patient should be placed in bed, and extension made by the

stirrup, weight and pulley in the direction in which the joint is displaced, the limb being gradually brought down in this way to a straight position. If the child is restless a long splint should be placed on the opposite limb to keep him from rolling to one or

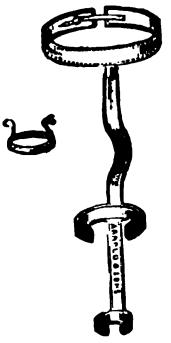


Fig. 561.—Thomas's hip-joint splint (front view) with patten.

Fig. 562.—Thomas's hip-joint splint applied. Patten on sound limb. (Heath's Minor Surgery.)

other side, whilst the foot of the bed should be raised by blocks to prevent him slipping down, or Bryant's double splint may be used with great advantage in some cases (Fig. 563). Subsequently, or at once in subacute cases, a Thomas's splint (Fig. 561) should be

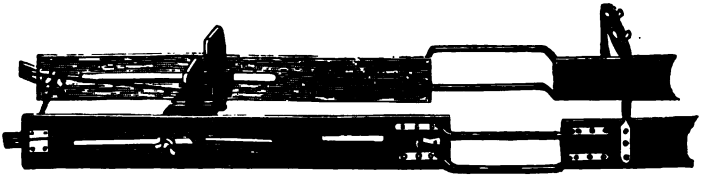


Fig. 563.—Bryant's splint.

applied, and after the limb has been brought into the straight position, the patient may be allowed to get about on crutches. If in spite of treatment, the disease progresses and pus forms, aspiration and the injection of iodoform-glycerine emulsion may first be tried, the aspiration and injection being repeated at frequent intervals. This failing, the abscess should be opened antiseptically, the diseased tissue scraped away with Barker's flushing-spoon, the cavity filled with

the iodoform emulsion and the wound closed. The head of the bone if loose or carious should be removed, as should also any carious bone that can safely be got away from the acetabulum. When all the carious bone cannot be removed, or the suppuration has extended into the pelvis, an antiseptic drain should be employed, the wound being stuffed with iodoform gauze daily. One advantage of early incision is that the pus in some cases may at first be outside the joint, being dependent upon disease about the great trochanter, lower end of the neck or upper end of the shaft, and so extension to the joint may be avoided. Many surgeons advise early excision of the head of the bone in the hope of shortening the duration of the disease, whilst others defer the removal of the head till after sinuses have formed and dislocation of the head has occurred. For early cases the anterior operation is to be preferred, for later the posterior, as thereby a better drain is obtained. All sinuses should be thoroughly scraped and the débris washed away with the flushing spoon. In intractable cases, where the pelvis is extensively involved, the soft parts are riddled with sinuses, the femur is in a state of osteomyelitis, and the patient is worn out by long-continued suppuration, hectic or lardaceous disease, amputation at the hip-joint is often the only chance of saving the patient's life. Where after excision of the head the limb is useless and flail-like, amputation may also be required. Should the patient recover but with the limb ankylosed in a flexed or other faulty position, the division of the femur subcutaneously with the chisel or Adams's saw below the trochanters will be required to put it straight.

Operations on the hip. — *Injection of the hip-joint.*—The hip-joint being extended, adducted and rotated inwards, a long needle is entered above the great trochanter at right angles to the long axis of the thigh and pushed on until it strikes the head or upper end of the neck of the femur (Fig. 564), along which it is guided until the freely moving point shows that it has entered the joint. If there is an external swelling this is selected, the line of the femoral artery in front and that of the great sciatic nerve behind being avoided.

Excision.—The hip may be excised—(1) when the head of the bone has become necrosed, and lies loose in the joint; (2) when suppuration continues in spite of free drainage and antiseptics; (3) when in addition to suppuration the head of the bone is dislocated, and the limb cannot be placed in a useful position. Excision should not be done when there is extensive disease of the pelvis or femur, or signs of lardaceous disease or of phthisis. Under these circumstances amputation is the only resource. For ankylosis in a faulty position subcutaneous osteotomy of the neck of the femur or of the shaft of the bone below the trochanters is preferable to excision. *The operation.*—1. By the *anterior* incision. Make an incision four inches long from half an inch below the anterior

superior iliac spine downwards and a little inwards between the sartorius and rectus on the inner side and the tensor vaginæ and glutei on the outer side, and open the joint from the front. 2. By the *posterior* incision. Make a slightly curved incision about four inches long behind the great trochanter, and after dividing the glutei, open the capsule from behind. Whichever incision is made insert the finger into the joint, and with this as a guide, cut through the neck of the femur with Adams's saw (Fig. 566), or Gowan's osteotome, and remove the head thus detached with sequestrum forceps. The great

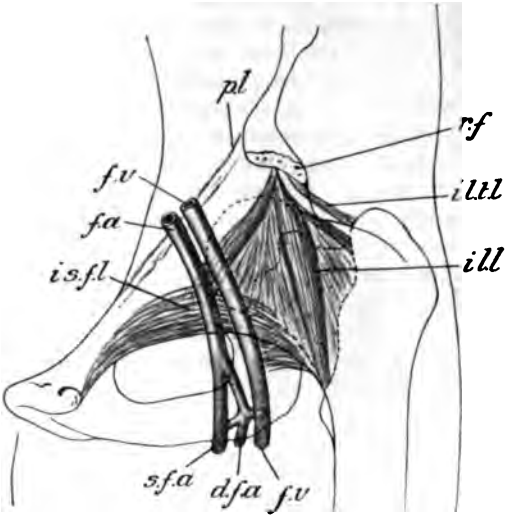


FIG. 564.—Relation of the hip-joint and its capsule to the vessels. *r.f.* Rectus femoris *il.t.l.* Ilio-trochanteric ligament. *il l.* Ilio-femoral ligament. *is.f.l.* Ischio-femoral ligament. *f.a.* Femoral artery. *s.f.a.* Superficial femoral artery. *d f.a.* Deep femoral artery with its external and internal circumflex branches. *f.v.* Femoral vein. *p.l.* Poupart's ligament.

trochanter should be spared if possible. It is important to avoid protruding the end of the bone out of the wound since the periosteum may in this way be stripped up and thus lead to further necrosis. Examine the acetabulum, and remove any carious bone or sequestrum that may be discovered with the gouge or sequestrum forceps, and finally scrape away every particle of the tuberculous synovial membrane that can be reached with a Barker's flushing spoon. Place the limb in the position of abduction on a double Thomas's splint, so as to bring the stump of the neck into the acetabulum, and thus leave as little space as possible between the bones. After ankylosis has taken place the abducted position is of advantage, in that to bring the limbs parallel in walking the pelvis will have to be depressed on the

affected side, and thus a good inch of lengthening is obtained to compensate for the shortening produced by the excision of the head of the bone. Most surgeons now no longer use a drain tube, but bring the deeper parts of the wound together by buried sutures, and having lightly closed the skin incision apply firm pressure over a dry

FIG. 565.—Section of the upper third of the thigh to show the relation of the structures divided in amputation of the hip. (After Braune, and Esmarch, and Kowalzig.) *f.* Femur. Muscles: *s.* Sartorius. *r.f.* Rectus femoris. *t.f.f.* Tensor fasciæ femoris. *v.* Vastus. *g.m.* Gluteus maximus. *st.* Semi-tendinosus. *sm.* Semi-membranosus. *a.m.* Adductor magnus. *a.b.* Adductor brevis. *gr.* Gracilis. *a.l.* Adductor longus. Vessels: *s.f.a.* Superficial femoral artery. *d.f.a.* Deep femoral artery. *d.f.p.a.* Deep femoral perforating artery. *g.a.* Gluteal artery. *s.a.* Sciatic artery. *s.f.v.* Superficial femoral vein. *d.f.v.* Deep femoral vein. *i.s.v.* Internal saphenous vein. Nerves: *a.c.n.b.* Anterior crural nerve branches. *s.n.* Sciatic nerve. *s.o.n.* Superficial obturator nerve. *d.o.n.* Deep obturator nerve.

antiseptic dressing, so as to keep the tissues in close apposition and thus obtain union by the first intention.

Amputation at the hip-joint (see Figs. 564, 565) is generally required for advanced hip-joint disease. It is occasionally performed for myeloid sarcoma of the upper end of the femur, when it will be successful if all the disease can be freely removed. It is the only treatment for periosteal sarcoma of the shaft of the femur, but the prognosis is hopeless. Primary amputation at the

hip comes under consideration in an extensive crush of the thigh or gunshot injury, but offers hardly any chance whilst the primary shock exists. The better plan is to try and check hæmorrhage, clean the wound as much as possible, pack with gauze and wait. The patient having rallied from the shock, and gangrene, sloughing or necrosis being imminent, amputation is indicated with a fair prospect of saving life.

The first step is to *control hæmorrhage*. Some place a pad over the femoral artery, over which an Esmarch's cord is tightly strained; some use compression of the abdominal aorta by hand or tourniquet. Wyeth introduces two long skewers external and internal to the femur and then applies the rubber band above. But there is one method, safe and applicable to all cases, and especially when a surgeon is unaccustomed to the operation, and that is, to divide the common femoral artery and vein, each between two ligatures (p. 419). In doing this a sufficient frill should be left on the distal side of the upper ligature to prevent slipping, and precautions taken that it is the common femoral which is tied. In the case of a high bifurcation, both superficial and deep femorals will require a ligature. There is then no further bleeding except from the region of the crucial anastomosis behind, the vessels forming which are easily picked up as divided. This preliminary ligature offers great advantage in tuberculous cases with sinuses, when the flaps have to be fashioned to suit the case. From the lower end of the longitudinal incision for tying the vessels, a circular incision is continued round the thigh (Furneaux Jordan), but is varied according to the sinuses and diseased skin to be avoided, so that the flap may be mainly anterior, antero-internal or postero-external, without approaching if possible the anal region. The patient is now brought over the end of the table on which his buttocks rest, and the sound leg is tied back, while an assistant holds the leg to be removed. The flaps being retracted the soft parts are cut through, commencing between the divided vessels, continuing across the front of the joint and above the great trochanter, whilst the femur is depressed to over-extend the hip. With further depression the knife passes behind the end of the bone and the soft parts are cut through in front of the ischial tuberosity. In doing so the vessels forming the crucial anastomosis are clamped and tied and the sciatic nerve cut as short as possible. Next all tuberculous, thickened and œdematous tissue is removed from the acetabulum and neighbourhood, and any carious bone gouged away. In some cases an extensive removal is required. The wound is united except for a gauze plug in the lower end, and is nursed with care to prevent contamination with fæces or urine. During the operation the patient may be infused with saline fluid (p. 207), and this may be repeated subsequently to the operation, or it may be given by the rectum with the pelvis elevated. These measures, combined with the preliminary ligature of the main

artery and vein, have rendered the operation successful for tuberculous cases. The transfixion method is no longer used.

Deformities of the hip.—*Rectangular ankylosis.*—In disease of the hip-joint the hip becomes flexed to a right angle and adducted whether slowly or gradually, and in this position it becomes fixed unless the tendency is overcome by long-continued extension. The fixation is partly the result of fibrous adhesions between the joint surface, partly of the shortening of muscles and ligaments. The fibrous adhesions gradually ossify (Fig. 135, p. 333). Meanwhile the femur from muscular disuse may undergo eccentric atrophy and the medullary cavity extend to the upper end of the shaft, even in a young patient, so that force applied to break down adhesions may readily cause a fracture in the upper third of the femur with fatal results from shock, fat embolism, suppuration or pyæmia. The patient walks with bent knees, on the toes, and with the lumbar spine curved in lordosis. Aching and pain result from the deformed posture of the diseased limb, or in the

Fig. 566.—Adams's osteotomy saw.

sound limb from having to bear the brunt of the body weight, a condition, however, which may be relieved by wearing a high boot with a cork sole. The flexed and adducted hip gives rise to difficulties in connection with marriage, and in child-bearing from a flattening of the pelvis on that side. When bilateral the adduction of each side causes the legs to cross, "scissor legs," and the patient can hardly move. A chance blow or strain, overwork or feeble health may light up again the tuberculous process, in which case, also when a fracture has occurred below the ankylosis, excision or amputation will be indicated. If the ankylosed joint is free from inflammation and the patient's health fairly good, osteotomy of the femur may be done in order to straighten the hip.

Subcutaneous osteotomy of the neck of the femur or of the shaft just below the trochanters may be undertaken. Division of the neck (*Adams's operation*) should only be performed when the neck of the femur is of its normal length. An incision about half an inch long is made midway between the top of the great trochanter and anterior superior iliac spine down to the bone, and through this the neck is divided transversely by an Adams's saw (Fig. 566). Subtrochanteric

osteotomy (*Gant's operation*) should be performed when the neck has been absorbed or the trochanter is bound to the pelvis by large masses of callus. A half-inch vertical incision just below the great trochanter is made to the bone and the shaft divided either by Adams's saw or the chisel. After either operation the limb should be placed in a Thomas's splint (Fig. 562) in a position of abduction, so that when union has occurred and the patient begins to walk the pelvis may be depressed on the affected side to bring the limbs parallel. In this way an inch of lengthening is regained. In ankylosis of both hips, in which the patient's limbs cross each other and so greatly interfere with progression (*scissor legs*), subtrochanteric osteotomy should be performed on each side. In young women with double ankylosis an attempt should be made to obtain a moveable joint on one side by removing a part of the neck or upper end of the shaft and gouging a cavity out of the callus through an open incision. When ankylosis is accompanied by much wasting of the limb, amputation may be necessary.

FIG. 567.—Coxa vara, showing the deformity of the head and neck of the femur (after Kocher). 1. Posterior view, left side. 2. Anterior view, left side. 3. Posterior view, right side. 4. Anterior view, right side. The neck is bent downwards to a right angle with the femur, whilst it is twisted so that the articular surface instead of looking upwards and inwards, looks downwards and backwards.

Coxa vara is a deformity resulting from curvature of the neck of the femur which is partly bent downwards so that the head of the bone approaches the level of the great trochanter and partly curved outwards giving an external rotation to the femur. The deformity is attributed to rickets, either slow and late, or not arrested in childhood (p. 308).

Signs. — Elevation of the

trochanter and marked eversion of the limb, so that in slight cases the patella cannot be rotated inwards beyond the middle line, and in a pronounced case not only looks outwards but even backwards and outwards. The result is limping from the shortening ($\frac{1}{4}$ to $2\frac{1}{2}$ inches) with the foot turned out, pain in the knee, and if bilateral a waddling gait. As the disease progresses there is with eversion more and more adduction, until, if bilateral, a scissor-legged deformity is set up. An examination of the upper end of the femur in such a case shows (Fig. 567) the head bent downwards and backwards, so that its articular surface looks downwards and backwards instead of outwards and upwards. Examined with the *x* rays the head and neck of the bone are observed, as compared with morbus coxæ and congenital dislocation. The other signs of morbus coxæ are absent. There is no abduction nor up and down movement met with as in congenital dislocation.

Fig. 568. — Photograph of a girl with congenital dislocation of the hip.

Treatment. — In slight cases in the young, rest with extension and inward rotation. In older well-marked cases, a subtrochanteric osteotomy, forcible rotation inwards and fixation by an aluminium plate is advised by Mr. Watson Cheyne. In adults, a wedge-shaped piece is excised from the neck with forcible rectification by Mr. Keetley.

Congenital dislocation of the hip from malformation of the joint.—In this deformity the acetabulum and head of the femur are malformed, the head of the bone resting usually on the ilium. The dislocation though at times unilateral is more often bilateral. The chief signs, which are usually first noticed when the child begins to walk, are a waddling gait, lordosis, and shortening of the limb if the dislocation is one-sided. On examination the trochanter is found to be prominent and above Nélaton's line, but it can be drawn down somewhat on making traction on the limb. The stunted head of the bone can usually be felt in the abnormal position. After the child begins to walk the adductor muscles become contracted and the head forced further from the acetabulum by the weight of the body; hence as the child grows the limb, if the dislocation is unilateral, gets gradually shorter. If bilateral the gradual contracture of the adductors increases the deformity.

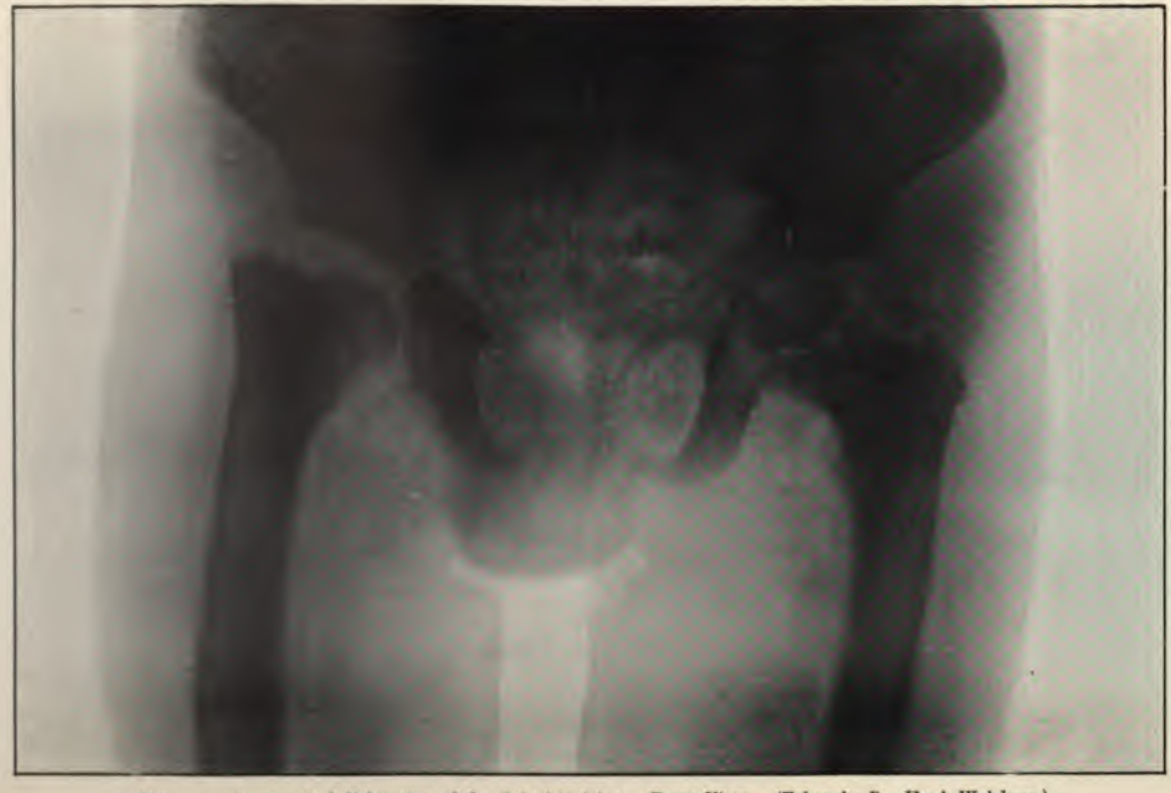
Diagnosis.—From *hip disease* early congenital dislocation may be

distinguished by the absence of pain and the freedom with which the joint can be manipulated in every direction especially in abduction; from *coxa vara*, in which the neck of the bone is bent down to more or less a right angle to the shaft, by the limited abduction in *coxa vara* in consequence of the raised trochanter coming into contact with the ilium when this movement is attempted, and by the absence in the *dislocation* of the head of the femur or acetabulum or of both, as seen by the *x* rays (see Plate XIX.).

Treatment.—Continuous extension in the horizontal position for two years with pressure over the trochanter has been attended with some success, but relapses are liable to occur. In young children up to five years of age the remains of the head may be often replaced in the rudimentary acetabulum by manipulation, or may be brought near that cavity. In either case the limb should then be fixed in the abducted position for many months, so that the pressure of the head may deepen the acetabulum or make for itself a new socket. For children between five and ten years of age, many surgeons strongly recommend an open operation, which may briefly be said to consist in the division of contracted muscles and ligaments, the gouging out of a new acetabulum in the ilium just below the anterior inferior spine so as to tilt the pelvis back, and the replacement of the remains of the head of the femur in the new socket thus formed. We confess that we have never seen much improvement from these methods, and we question if the results obtained are worth the risk. For still older patients a high boot may be prescribed, and the height of the sole increased from time to time as required.

Recently Lorenz has brought into prominence his method of forcible reduction. The head of the bone is loosened by free circumduction, contracted adductors are ruptured by chopping with the edge of the hand and by pressure with the thumbs, and the head is forced forwards until it is felt below Poupart's ligament. Then the limbs are fixed in extreme abduction, and well rotated outwards. This fixation is accomplished by a double spica plaster bandage over drawers, which have a slit for the genitals and anus. Next the skin are laid strips of bandage, the ends reaching above and below the plaster. By see-sawing on the ends of the bandages the débris from the skin is removed, and thus irritation is avoided. On reapplying the bandage the limbs are brought down to about half a right angle of abduction, and the child is allowed to move about and to get astride a hobby-horse with the object of mechanically deepening an acetabulum and encouraging muscular development. The *complications* which have followed have been grave or even fatal, shock, subcutaneous extravasation of blood, fracture of the femur, and the hernia cruralis prevascularis mentioned on p. 927. No one has yet demonstrated a definite and permanent improvement by this method, but it may be held that the arrest of the increasing adduction is valuable.

PLATE XIX.



Skiagram of congenital dislocation of the right hip-joint. Front View. (Taken by Dr. Hugh Walsham.)

Diseases of the Shaft and Lower End of the Femur.

Septic inflammation.—The lower end of the shaft of the femur is one of the commonest situations for septic osteomyelitis. The less frequent affection of the upper end has been alluded to in connection with the hip-joint. Septic inflammation of the lower end forms the typical description of the disease noted on p. 315. It commences most often in boys about puberty, after or without an injury, with an attack of obscure pain above the knee. A swelling follows, and if the disease is very acute there is high fever, and within a day or two the formation of pus in the centre of the end of the diaphysis, with softening of the neighbouring bone, pus beneath the periosteum, and thrombosis of small veins around. If the septic thrombosis follows in the popliteal or superficial femoral vein, septic emboli may be carried to the lungs and pyæmia sets in. The treatment should be prompt—an incision down to the periosteum and boring into the shaft immediately above the epiphysis. If pyæmic symptoms are commencing, amputation is done at once above the disease. If the disease takes a subacute course, pus spreads beneath the periosteum and more or less of the lower end of the femur, in particular the popliteal surface, becomes necrosed and must be chiselled away, or the disease may extend towards the medullary canal; there is then general thickening of the bone from the formation of new periosteal bone, whilst within more or less of the old shaft undergoes necrosis (*central necrosis*). Sinuses then form, leading down to a sequestrum enclosed in an involucrum; or the pus may become partly absorbed and changed into an oily fluid (the so-called *quiet necrosis* without suppuration), and a thickening of the femur appears which is difficult to distinguish from syphilitic disease or sarcoma until explored, when a cavity will be found containing a sequestrum, unless this has been slowly absorbed. At any time spontaneous fracture may occur, and some cases have been noted of sarcoma supervening on the quiet necrosis. An incision down to the bone is made and a groove cut with an angular gouge extending up the bone as far as the central necrosis, even its whole length up to the trochanter; the medullary cavity is then scraped out and packed with gauze and will finally fill up with granulations.

Tumours of the femur, like inflammation, especially affect the lower half of the femur.

An *exostosis* starts from the lower end of the diaphysis at the epiphysial line (Plate IV., p. 358), but as the bone grows is carried upwards, so that at puberty it appears to be attached near the junction of the lower with the middle third. It is pedunculated, mushroom-shaped, covered with a layer of cartilage and a bursa which may become distended. The neck of the exostosis may fracture and the exostosis become loose and set up suppuration, or

if on the posterior aspect, cause an aneurysm of the popliteal artery. The pedunculated form is easily removed with a chisel. A sessile multiple form of exostosis is seen in connection with rickets, and may end in sarcoma.

Cysts of the femur are hydatid, or may be the result of quiet necrosis, and may not be noticed until there is a spontaneous fracture, when amputation is generally indicated.

Swelling due to *callus* is occasionally seen after fracture in a rickety child and may be mistaken for a tumour.

Gumma of the femur, acquired or inherited, appears as a rapidly-developing thickening of the femur, which, if in the middle of the shaft, is likely to be confused with periosteal sarcoma. At the lower end of the bone it resembles not only periosteal sarcoma, but also endosteal myeloid sarcoma and central osteomyelitis. If the tumour be suspected to be syphilitic, the patient should be treated for ten or fourteen days with iodide of potassium and mercury in full doses. If no satisfactory improvement results, the tumour should be incised, when little yellow points of degeneration may be seen on the section. A piece of the tumour should be removed and should be examined microscopically, whilst the wound is filled with gauze and the antisyphilitic remedies continued till a report of its nature has been obtained.

Sarcoma.—The lower third of the femur is the typical seat of sarcoma. A *myeloid sarcoma* is of slow growth, uniformly enlarging the bone without pain or inflammation, a gumma is excluded by drugs, quiet necrosis by incision. The tumour on section will appear of a maroon colour, be cystic or contain blood. The shell in which it is enclosed may be evacuated, or the lower end of the femur excised and the surface of the tibia being cut off, the two bony ends are united ; or amputation may be done with a practical certainty of curing the patient. A myeloid sarcoma at the upper end of the femur is similarly treated by evacuation of the shell, excision of the upper end of the bone, or amputation at the hip-joint.

Periosteal sarcoma is the most malignant of all growths. Secondary growths always follow in the inguinal and lumbar glands. There may also be enlargements of the liver, scattered growths on the surface of the lungs, with hæmorrhagic pleural effusion—indeed, the last seems to be a very common sequence. A periosteal sarcoma being found on exploration, amputation at the hip-joint, with excision of the glands in Scarpa's triangle should be done. In this way life may be prolonged from the time of operation for six to twelve months ; the longest time we have ourselves known is fifteen months, the stump remaining sound and the signs of secondary growth being ushered in by a pleural effusion. Cases of sarcoma stated to be cured by amputation are central myeloid sarcoma, gumma, quiet necrosis, callus tumour, or alveolar hydatids.

Metastatic tumours may form in the femur and cause spontaneous fracture, but the patient is bedridden, and no special surgical treatment is required.

Amputation through the thigh (see Fig. 569).—Preference may be given to amputation through the condyles or immediately above, for the medullary cavity is not opened; next, to amputation below

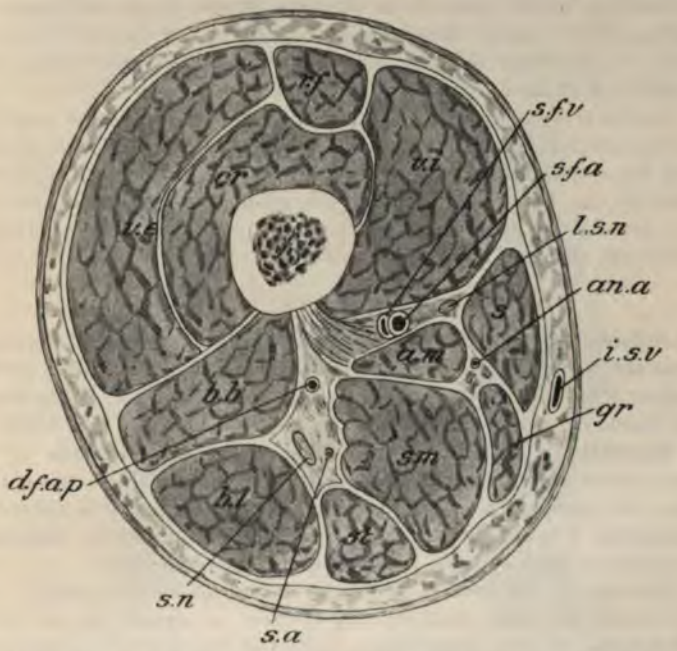


FIG. 569.—Section of the thigh at the junction of the middle and lower third to show the structures divided in an amputation. (After Braune and Esmarch, and Kowalzig.) *f.* Femur. Muscles: *v.i.* Vastus internus. *r.f.* Rectus femoris. *cr.* Crureus. *v.e.* Vastus externus. *b.b., b.l.* Short and long head of the biceps. *st.* Semi-tendinosus. *sm.* Semi-membranosus. *gr.* Gracilis. *s.* Sartorius. *a.m.* Adductor magnus, artery about to pass through. Vessels: *s.f.a.* Superficial femoral artery. *an.a.* Anastomotic artery. *d.f.a.p.* Deep femoral artery perforating. *s.a.* Sciatic artery. *s.f.v.* Superficial femoral vein. *i.s.v.* Internal saphenous vein. Nerves: *s.n.* Sciatic nerve. *l.s.n.* Long saphenous nerve.

the middle of the bone, because an artificial limb can be worn. Amputation through the upper third is almost as dangerous as regards shock, etc., as through the hip-joint, and has not the advantage of removing the whole bone when operating for sarcoma or necrosis; moreover, an apparatus cannot be easily attached to the stump. Amputation through the thigh is required for injury, gangrene, septic and tuberculous diseases of joints, malignant disease whether of the skin or soft parts—*e.g.*, following chronic ulcer of the leg.

The flaps taken are commonly lateral, so that drainage takes place through the posterior angle, and the contraction draws the scar backwards off the line of pressure; their combined length must be two diameters of the limb at the level of the division of the bone, or a pointed stump will form; the femoral artery and vein should be drawn out of their sheath and tied before removing the tourniquet. The sciatic nerve should be shortened to prevent irritation, and the stump, which tends to be elevated by the psoas and iliacus, is bandaged to a short broad splint which can be tied down to the bed, or a sand-bag is placed across it, or extension by weight over a pulley is applied.

Carden's method, designed for amputating through the condyles of the femur, consists in reflecting a semi-oval flap of integuments, half the circumference of the limb in length and breadth, from the front of the knee-joint, dividing everything else down to the bone by a circular sweep of the knife, and sawing the bone across slightly above the plane of the divided muscles.

Diseases and Deformities of the Knee.

Inflammations of the knee, on account of their frequent occurrence, form the typical conditions described on p. 324 *et seq.* Whilst the patient is in bed his knee is kept straight on a back splint. When he can get about he can do so on Thomas's knee-joint splint (Fig. 570).

Operations on the knee.—*Aspiration and injection of the knee* can be done on either side of the patella, or above the patella when the synovial pouch under the quadriceps extensor is distended. Aspiration is useful both for the relief of tension and for diagnosis; injection is most suitable in tuberculous hydrarthrosis.

Incision of the joint is made on either side of the patella, over the inner or outer condyle, and if there is already an extension backwards of the suppuration, whether distending the synovial pouches behind the condyle (Fig. 572, *k.j.*), or having perforated through the posterior ligament, a counter-opening may be made in the popliteal space by cutting down upon blunt-pointed forceps pushed backwards from the joint. The popliteal vessels and nerves must be avoided.

Arthrectomy is generally required for tuberculous disease in patients under puberty. After that age excision is generally indicated, although exceptionally a thickened synovial membrane without bone disease may suggest its performance.

If an elastic tourniquet is employed, the dressings, with abundance of wool and a firm bandage, should be applied before the tourniquet is removed and the limb kept elevated. This prevents the oozing of blood, which is the objection raised to the use of a tourniquet, but it seems, however, to be advantageous in anæmic children. A rectangular flap is then turned up so as to expose the joint. In making the transverse cut the tubercle of the tibia should be cut off, so

that it remains attached to the patella and the ligamentum patellæ, and at the end of the operation is refixed in position where the bony surfaces readily unite. Some cut across the ligament; the objection to this is that there may be stretching after union, so that the action of the quadriceps is weakened. Others cut the patella across and wire it together afterwards, by which some risk is run of necrosis and non-union. The side incisions run just in front of the lateral ligaments, and are continued well above the patella, so that the synovial pouch (Fig. 146, 1, p. 374) shall be fully exposed. All the synovial membrane is now dissected and scraped away, the surface of the lateral ligament is cleared without being injured, the crucial

Fig. 570.—Thomas's knee-joint splint with foot-piece for extension. (Heath's Minor Surgery.)

Fig. 571.—Thomas's knee-joint splint applied. Patten on sound limb. (Heath's Minor Surgery.)

ligaments and the semilunar cartilages are taken away, and by flexing the knee well, the anterior face of the posterior ligament is cleaned. Loosened cartilage and carious bone is gouged out, iodoform dusted on the surface, and the skin sutured down, if possible without drainage. The limb is kept straight on a splint, and after healing in a plaster case or rubber splint for at least a year, until there is good firm ankylosis. It is inadvisable to try for movement; the joint keeps hot and relapse follows, or the knee gets finally ankylosed in a position of flexion.

Excision of the knee.—The suitable age for this operation is between sixteen and thirty. Below and above these ages it is rare for a useful limb to be obtained. Above thirty, if the disease has progressed so far, amputation is generally to be selected.

The knee may be excised for intractable disease of the synovial membrane, especially where the articular surfaces are much displaced, or for ankylosis in a faulty position. In the latter instance, however, a subcutaneous osteotomy is often preferable. *The operation.*—The knee being held in a flexed position by an assistant, make an incision from the posterior part of the condyle on one side, across the front of the joint midway between the patella and the tubercle of the tibia, to

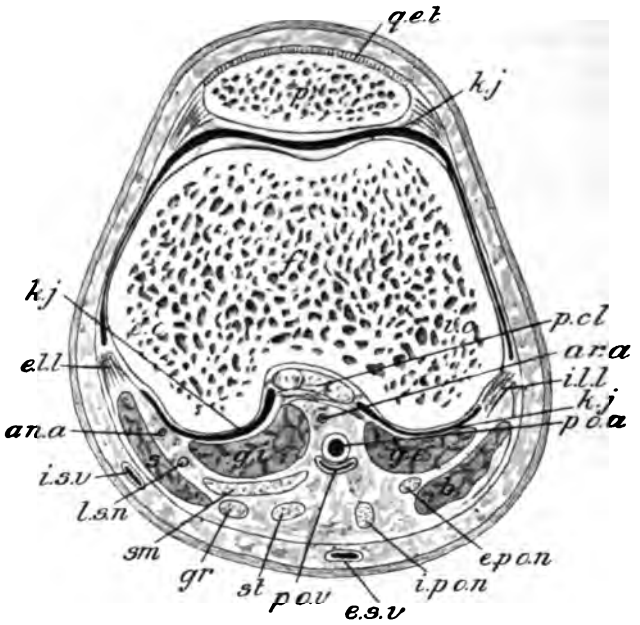


FIG. 572.—Section through the condyles of the femur, to show the relations of the structures. (After Braune and Esmarch, and Kowalzig.) *f.* Femur. *p.* Patella. Muscles: *g.i.*, *g.e.* External and internal head of the gastrocnemius. *s.* Sartorius. *sm.* Semi-membranosus. *gr.* Gracilis. *st.* Semi-tendinosus. *b.* Biceps. *k.j.* Knee-joint. *i.l.l.*, *e.l.l.* Internal and external lateral ligament. *p.c.l.* Posterior and crucial ligaments. Vessels: *po.a.* Popliteal artery. *ar.a.* Articular branch. *an.a.* Anastomotic artery. *po.v.* Popliteal vein. *i.s.v.* Internal saphenous vein. *e.s.v.* External saphenous vein. Nerves: *e.po.n.* External popliteal nerve. *i.po.n.* Internal popliteal nerve. *l.s.n.* Long saphenous nerve.

the corresponding situation on the other. Raise the flap of skin with the subcutaneous tissue thus mapped out, and open the joint by cutting into it above the patella, or the patella may be sawn across and the fragments wired at the end of the operation. Divide the lateral and crucial ligaments, and saw off a thin slice of bone from the lower end of the femur and from the upper end of the tibia, taking care not to injure the popliteal artery which lies close to the back of the joint (Fig. 572), and is only separated from it by the

posterior ligament. If the patella is left the layer of cartilage is shaved off. If possible the whole of the epiphysis of the femur or tibia should not be removed. The wound should then be closed with sutures. A small drain may be inserted on each side, but it is not necessary. Mr. Morrant Baker secured the articular surfaces in contact by means of steel needles fitted with handles. The needles, large sized steel knitting needles, are passed through the skin of the leg and obliquely through the bones on each side of the joint, the handles removed, and the needles left *in situ* till union has occurred. Others substitute bone pegs for the needles, passing the pegs along the holes made by the needles. The pegs are then cut off short and left in permanently. Tenotomy of the hamstring tendons may be required to bring the bones into apposition if there has been much displacement. The limb should then be placed in plaster of Paris or on a Gant's or other form of excision splint; but the kind of splint is not very material if the bones are well secured in good position by the pegs in the way described above. After convalescence the knee should be kept for at least a year in a well-fitting leather splint, as there is a great tendency for the bone to yield and the limb to become flexed.

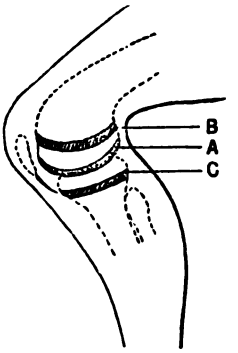


Fig. 573.—Line of incision in the circular division of the femur for ankylosis of the knee in the semiflexed position. A, line of incision; B and C, line of epiphyses.

Deformities about the knee. — *Ankylosis in a semiflexed position.*—When recent and fibrous, gradual extension by weight combined with a sand-bag on the knee may be effectual, but not if there is already partial dislocation backwards and rotation outwards of the tibia. Forcible extension, except in very recent cases, should rarely if ever be done. The complications which follow are hæmorrhage leading to suppuration, rupture of the popliteal vessels shortened by the prolonged flexion, causing diffuse aneurysm and gangrene necessitating amputation, or fracture of the atrophied femur. An open operation is always much better. Division of the adhesions, arthrectomy, and tenotomy of the hamstrings, or the excision of a wedge of bone from the femur and tibia, had better be done, or in place of removing a wedge of bone a curved incision may be made through the bone with Butcher's saw, and the tibia thus slid round the femur into the straight position (Fig. 573). By this last method no bone is removed, and the epiphyses being spared there is less danger of a shortened limb. Walsham has obtained excellent results from it.

Contraction of the hamstring tendons.—The tendon is drawn to

the surface and cut through by means of a hook through a short incision. Subcutaneous tenotomy is dangerous; thus the external popliteal nerve may be mistaken for the biceps tendon.

Knock-knee or genu valgum is a deformity in which, when the knees are placed together in the extended position with the patellæ looking directly forwards, the legs diverge. One or both knees may be affected, or there may be genu valgum on one side and genu varum on the other.

Cause.—Knock-knee is generally the result either of rickets, when it occurs between the second and the seventh year; or of carrying heavy weights, long standing and the like, when it is most common in growing, underfed and overworked lads and girls from fourteen to eighteen. This tendency to bend is often spoken of as late rickets (p. 308). The result is that, whether from an S-shaped rickety curve in the young, or from long standing causing flat-foot in older boys and girls, there is an excess of pressure on the outer half of the lower femoral and upper tibial epiphyses checking growth, which continues at the normal rate on the inner side, so that the inner condyle of the femur projects below the outer and the inner tibial tuberosity above the outer. Favouring further development is a relaxation of the internal lateral ligament and a contraction of the biceps. In the majority of cases the osseous lesion is certainly present, and it is upon this that the deformity in rickety cases usually depends, though it must be admitted that in some of those rapid cases induced by excessive weight-bearing in weakly lads a relaxation of the ligaments may be the principal factor. The contraction of the biceps tendon when present should be regarded as the result, and not as the cause of the affection. The bony deformity differs; in some cases it is chiefly the excessive length of the internal condyle which projects under when the knee is bent and the plane of the knee-joint is no longer horizontal but slopes from the inside upwards and outwards. In other cases it is the inner tuberosity of the tibia which produces the deformity. The *x* rays serve as a means of distinguishing between the two forms.

Treatment.—In slight rickety cases, keeping the child entirely off its legs, the application of splints, and the internal use of appropriate remedies, will generally effect a cure. In confirmed cases, and in older patients, however, little must be expected from splints or instruments. By their use the limb can no doubt be straightened, but only at the expense of stretching the external lateral ligament, the legs being rendered flail-like, and the patient being unable to walk or even stand without his irons. For such some form of osteoclasia or osteotomy is usually required.

(A) *Osteoclasia* consists in breaking the bone either with the hands or with the *osteoclast*. Manual osteoclasia is seldom employed except for the correction of rickety bow-legs or knock-knee in young children when the bones are moderately soft. For fracturing larger and stronger bones the osteoclast is required. The limb is properly

adjusted between the arms of the instrument and the force applied by levers in Thomas's osteoclast or by means of a screw in Grattan's.

(B) *Osteotomy* is usually done on the femur by Macewen's or Reeves' modified Ogston's method. 1. *Macewen's operation* consists in chiselling through the femur just above the epiphysis, but leaving the posterior surface, which is in contact with the popliteal artery, intact, and snapping this across by forcibly bending the bone. 2. In *Reeves' modification of Ogston's operation* the internal condyle is first loosened with a chisel, and then made to slide upwards on the shaft of the femur by forcibly straightening the leg. The chisel is introduced behind the synovial membrane and should not be driven so far into the condyle as to endanger the opening of the joint. The line of incision through the femur in these operations is shown in Fig. 574. The incision in the soft tissues which in either operation should be merely long enough to admit the osteotome, may in each be made vertically two fingers' breadth above the patella and midway between the inner edge of the rectus and the tendon of the adductor magnus. 3. When it is the inner tuberosity of the tibia which causes most of the deformity some prefer to excise a wedge-shaped piece out of the tibia, then to cut through or break the fibula. In a very bad case both femur and tibia may be divided. In any case the leg must be bent well inwards, and the tendency of the biceps in particular to reproduce the deformity prevented. The operation must be performed antiseptically and the limb secured to a long splint, or placed in Bavarian plaster splints in a straight position for about a month, and subsequently kept in an ordinary plaster case for six weeks to two months till sound union has taken place.

FIG. 574.—A, line of section in Macewen's; B, in Ogston's; and C, in Reeves' modified Ogston's operation; D, removal of wedge from tibia (after Morton).

Genu varum, or bow-legs, is the opposite deformity to genu valgum, and what has been said of the latter as regards pathology, treatment, etc., will apply to it if external be substituted for internal in the phraseology. It is frequently associated with a bowing of the shaft of the tibia, either at its upper or its lower third, and sometimes with a bowing of the femur, including the neck, *coxa vara* (p. 1148).

Genu recurvatum or retrorsum is a condition of over-extension at the knee. It is frequently present in a slight degree in cases of knock-knee. It sometimes occurs as a congenital affection; the hyperextension may then be extreme, the feet touching the groins. When it is combined with knock-knee the irons for the latter affection should have a front stop. In congenital cases division of the

quadriceps may be necessary, but continual attempts at flexion and the use of an instrument with a cog-wheel at the knee will usually suffice.

Flail knee.—*Arthrodesis.*—When as the result of infantile paralysis the knee is unable to support the weight of the body yet the femur can be moved by the psoas and iliacus, a resection of the knee-joint, with the object of obtaining bony union, is indicated.

Amputation through the knee may be done whenever the skin of the upper third of the leg can be utilised for flaps. It is perhaps best done by lateral flaps after Stephen Smith's method. Two lateral skin flaps are cut, the inner a little the longer, from each side of the upper third of the leg, the incisions beginning in front, an inch below the tubercle of the tibia, and ending behind at the centre of the popliteal space. The soft tissues are next divided by a circular sweep of the knife by strongly flexing the knee and entering the point of the knife between the semilunar cartilages and the tibia, the ligamentum patellæ and crucial ligament are at the same time cut through, so that the semilunar cartilages remain on the condyles of the femur, and with a continuation of the cut all the popliteal structures are divided. The stump (Fig. 572) is then seen to contain practically no muscle; the popliteal artery and vein which closely adhere have to be separated, and are the only large vessels requiring to be tied. The nerves are shortened and the skin sewn up. The result is a broad cushion below the condyles of the femur upon which the patient can soon walk, and the apparatus can be fitted at an early date, for there is no muscle to waste. The scar lies between the condyles and is gradually drawn up behind. The patient retains the full leverage of the femur as the quadriceps continues to act on the end of the bone. The one difficulty is the length of flap required to cover the broad condyles.

Bursæ and cysts about the knee-joint (see p. 373).

Popliteal aneurysm (see p. 403).

Popliteal abscess (see p. 446).

Diseases of the Leg and Foot.

Ulcer of the leg (see p. 33).

Varicose veins (see p. 428).

Diseases of the Leg-bones.—*Septic inflammation of the tibia and fibula* is very frequently traumatic in origin owing to the superficial position of the tibia and its liability to compound fracture. It is also due to ulceration, syphilitic, malignant, etc., extending to the bone. Septic osteomyelitis due to staphylococci and tuberculous osteomyelitis, is most frequent at the upper end of the tibia, then at the lower end, and least frequent in the fibula.

Inflammation commencing in the middle of the bone, is usually periosteal, due to typhoid fever or syphilis. An acute swelling forms, and being cut into pus is found beneath the periosteum, or the bone of the end of the diaphysis is found softened and breaking

down into pus. If not quickly let out, the pus raises the periosteum throughout the shaft and necrosis results, necessitating the removal of the whole diaphysis. The unaffected bone maintains the leg in position until a new shaft has formed.

Both the upper and lower end of the tibia may become enlarged, and over a limited area very painful to pressure, owing to a central abscess with necrosis. (See further pp. 312 *et seq.*)

Malignant disease of the leg bones.—*Myeloid sarcoma* arises most commonly in the head of the tibia, next in the cancellous tissue of the lower end. It may undergo myxomatous degeneration, become filled with blood and pulsate, but some sarcomatous material remains in the wall. It is a question whether a true aneurysm (p. 364) does exceptionally develop in the head. A slowly increasing swelling, a gumma being excluded, should be explored, and will prove to be either myeloid sarcoma or quiet necrosis. Evacuation from its shell will suffice in the early stage; if it has already spread beyond, amputation immediately above can be regarded with confidence as a cure.

Periosteal sarcomas form on the shin following injury, but, as is evident, there must be some pre-existing tendency in the patient, as there is no part so commonly exposed to small injuries. The growth is rapid; a gumma being excluded, amputation through the lower third of the thigh with excision of the glands in the groin offers the only hope, but the prognosis as to recurrence is unfavourable.

Callus tumours of a less malignant nature may be seen.

Squamous-celled carcinoma.—From the epitheliomatous degeneration of an ulcer (it has been found occasionally to be sarcoma), epithelioma infiltrates the tibia, reaches the medullary cavity, and may be complicated by septic necrosis. A small piece may be cut out of the ulcer and examined microscopically. Amputation is required either through the upper third of the leg, the knee-joint, or lower third of the femur with excision of the glands in the groin. The prognosis as to cure is good if the disease is not left too long.

Amputation through the leg (Fig. 170, p. 423) is indicated for injury when the foot or lower third of the leg is so far smashed that all three of the main arteries are occluded, also for extensive septic and tuberculous disease, elephantiasis and madura foot, but not for senile and diabetic gangrene, for which amputation through the thigh is required.

Amputation through the leg is generally done by antero-lateral and postero-lateral flaps (Fig. 547), the two being in length about one and a half times the diameter of the limb at the level of the division of the bone. The antero-lateral flap must be raised by keeping the edge of the knife throughout against the bone and interosseous membrane, so that the anterior tibial artery can run to the end of the flap without injury. The longer this flap, especially in Teale's amputation (Fig. 548), the more important it is that the artery should not be injured. The postero-lateral flap includes skin and

subcutaneous tissue but no muscle, the muscle being cut through in a circular fashion behind. The division of the fibula by the saw should be completed before the tibia to avoid splintering. The sharp edge of the tibia must be sawn off obliquely, so that it shall not subsequently protrude.

Diseases of the Ankle-joint and Foot.—*Inflammations commencing in the ankle-joint* are rare, except traumatic inflammation from sprains.

Suppurative arthritis may extend from a septic inflammation of the tibia or be pyæmic.

Tuberculous disease of the ankle generally commences in the neighbouring bones, tibia or astragalus, or between the astragalus and os calcis. Aching pain, stiffness in the joint, pain in the heel, heat over the malleoli, bulging of the tendons in front, or filling up of the spaces on either side of the tendo Achillis in a young patient, later goes on to suppuration and the formation of sinuses with caries of the adjacent bones.

Tuberculous disease may appear in the foot first as distension of a tendon sheath to form a ganglion, a bulging of the synovial membrane between one of the tarsal bones, pain on deep pressure, induration and superficial œdema, finally suppuration and formation of sinuses with progressive caries.

Treatment.—Rest. The foot is fixed at a right angle to the leg in a plaster or silicate bandage. The patient can get about, with the knee bent to a right angle on a kneeling pin fitted with a leg rest, or he may use a Thomas's knee-joint splint (Figs. 570, 571).

Operations on the ankle and foot for tuberculous disease.—*Injections* may be made below or in front of the tips of the malleoli or on either side of the tendo Achillis into the joint, or into the sides or dorsum of the foot.

Arthrectomy of the ankle.—The joint may be exposed from the outer or inner side or by cutting across the front. If the last method is employed the tendons and nerves should be sutured at the end of the operation. It may also be done by cutting across the os calcis from below, as in Pirogoff's amputation, and flexing the foot till the instep touches the leg. The astragalus is thus carried forwards, also the lateral ligaments, and the joint is entered from behind. At the end of the operation the divided os calcis is fixed together. This is the only method of doing arthrectomy without injuring important structures.

Excision of the ankle-joint is rarely of service. The division of the lateral ligaments and the loss of the malleoli leave the joint so weak. The best method is an extension of the posterior arthrectomy just described (Mikulicz's method). After flexing the foot till the instep touches the leg, the astragalus can be removed, the inner side of the malleoli, the under surface of the tibia, the tibio-fibular articulation, the adjacent tendons can all be well scraped, and then

the os calcis united and the foot kept fixed at a right angle. We have obtained good union by this operation.

Excision of the os calcis is indicated when the tuberculous disease begins in the os calcis or is situated between that bone and the astragalus. A horizontal incision is made (Fig. 575, 1) round the heel immediately above the sole, commencing from the inner side

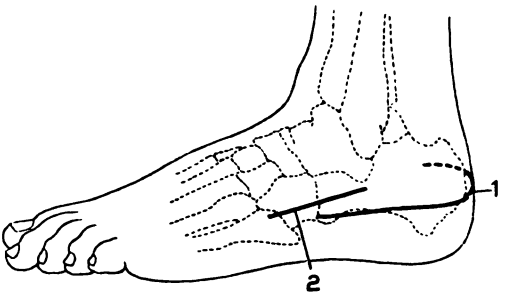


Fig. 575.—Excision of the os calcis.

behind the sustentaculum tali so as not to injure the plantar arteries and nerves, and ending at the calcaneo-cuboid articulation. The bone is removed after retracting the flap, the tendo Achillis sutured to the astragalus and sole, and the flap sutured in position. The scar is not pressed on, but the patient becomes flat-footed from the astragalus sinking down. Any tendency to inversion must be

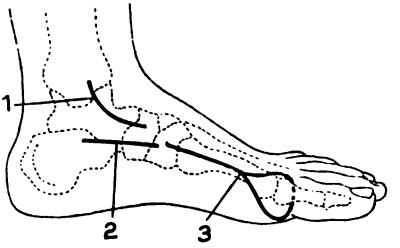


Fig. 576.—Incisions on the inner side of the foot. 1. Excision of the astragalus. 2. Excision of the scaphoid. 3. Amputation of the great toe.

corrected. Or the calcaneo-cuboid joint can be excised by an incision over it (Fig. 575, 2).

Excision of the astragalus may be done in excising the ankle-joint. It can also be done in front, especially when required for dislocation or to rectify club-foot, by an incision in the line of the dorsal tendons which are retracted (Fig. 576, 1).

Tuberculous disease of the anterior tarsus and metatarsus may be dealt with by cutting down over the bones, by splitting the foot down

the middle between two of the toes and retracting each side, or by excising the bones of the anterior tarsus, also the bones of the metatarsus by making two lateral incisions, then raising the soft parts by undermining with raspatories.

The tumours of the foot are fibromas and myeloid sarcomas.

Deformities of the Foot.

Talipes is a distortion in which the relations of the tarsal bones to each other and to the bones of the leg are variously altered, and the bones held in their abnormal position by alteration in the shape of the bones and by the contraction or shortening of certain of the muscles, ligaments, and fasciæ attached to the foot.

Cause.—Talipes may either be congenital or acquired.

The *congenital* form has been attributed to—1, spastic muscular contraction induced by some lesion of the nerve-centres; 2, malpositions of the fœtus *in utero*; 3, structural alteration in the form of some of the tarsal bones. The supporters of the first view maintain that the bones are drawn into their abnormal position by muscular contraction, and regard any alteration in the shape of the bones as the result and not as the cause of their malposition; whilst those who uphold the second and third views deny that spastic contraction occurs, as no lesion of the nerve-centres has been found to account for it, and look upon the contraction of the muscles as merely due to adaptive shortening consequent upon the altered position of the bones. The congenital variety is sometimes hereditary, very occasionally occurs in several members of the same family, and is frequently associated with other congenital malformations as spina bifida, meningocele, etc. The *acquired* form is generally the result of infantile paralysis, the bones then either being drawn into their abnormal positions by the contraction of the muscles antagonistic to those paralysed, or falling into the abnormal positions by the weight of the foot. In either case the weight of the body in standing and walking tends more and more to confirm this faulty position. Amongst other causes may be mentioned long continuance of the foot in the extended position, disease of the ankle or tarsus, yielding of the ligaments, etc.

Talipes equinus (Figs. 577, 578) is nearly always an acquired affection, and generally due to infantile paralysis of the anterior or extensor muscles; as a congenital affection it is very rare. Walsham saw two cases only during the seventeen years he had charge of the orthopædic department of St. Bartholomew's. The heel is drawn upwards by the tendo Achillis, and the anterior part of the foot is in consequence depressed and held in the extended position. The weight of the body is thus transmitted through the heads of the metatarsal bones, which, together with the anterior

part of the tarsus, are bent downwards and backwards from the transverse tarsal joint and fixed in this position by the adaptive shortening of the plantar fascia, ligaments and muscles, thus rendering the sole of the foot unnaturally concave, a condition known as *pes cavus*. The patient walks with fatigue and lameness on the balls of his toes (Fig. 577), and if both feet are affected he may be unable to walk at all. When the extensor muscles of the toes are completely paralysed the toes may be bent under as shown in Fig. 578, and the patient walks on the dorsum of the toes, or even on the dorsum of the foot. Corns and perhaps ulcers are then formed, rendering walking exceedingly painful or impossible. In long-standing cases, in consequence of the contraction being greater on the inner than on the outer side of the sole, an inward twist is given to the foot (*equino-varus*). At times the tendo Achillis is not sufficiently shortened to draw up the heel, but at the same time is so contracted as to prevent the foot being placed beyond a right angle with the leg. This condition is spoken of as *right-angled contraction* of the tendo Achillis or as *rectangular talipes*.

FIG. 577.—Talipes equinus. (Bryant's Surgery.)

FIG. 578.—Talipes equinus, with complete paralysis of the anterior muscles.

Talipes varus is the most complicated variety of club-foot, and is the most common of the congenital forms. By some the distortion here described as varus is called *equino-varus*. We prefer, however, to apply the simple term *varus* to the form under consideration, and *equino-varus* to cases of equinus in which there is added a secondary twisting inwards of the foot. In varus (Fig. 579), the os calcis is drawn up by the tendo Achillis, tilting the astragalus partially out of the ankle-joint, and the bones in front of the transverse tarsal

FIG. 579. — Congenital talipes varus. (St. Bartholomew's Hospital Museum.)

joint are drawn inwards and upwards by the tibialis anticus and posticus, so that the scaphoid is placed internal to the astragalus instead of in front of it, whilst its tuberosity is in close contact with the internal malleolus. The ligaments on the inner side of the sole and between the tibia and astragalus are shortened, and are often the chief agents holding the bones in their deformed position. In severe cases, however, the astragalus is itself deformed, its head looking almost directly inwards instead of forwards and slightly

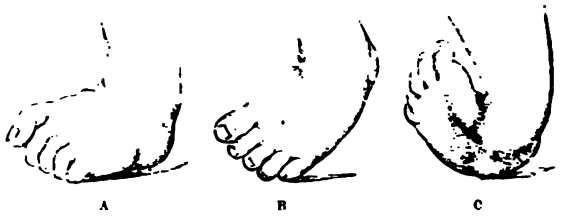


Fig. 580.—Congenital varus. Three grades of severity. Bryant's Surgery.

inwards. Thus, in a well-marked case (Fig. 580, A and B), the heel appears drawn up, the anterior part of the foot adducted and inverted, the inner border turned upwards or inverted, and the outer border downwards, so that the sole looks backwards and the dorsum forwards, the long axis of the foot being at the same time shortened and bent upon itself, the sole unnaturally concave, and the plantar fascia tense. In severe cases (Fig. 580, C), the inner border of the

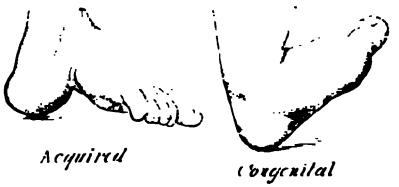


Fig. 581.—Talipes calcaneus. (Bryant's Surgery.)

foot may be in contact with the leg, and when the foot has been walked upon the sole looks upwards as well as backwards, and the dorsum downwards as well as forwards; whilst the sole is narrowed by the approximation of the fifth metatarsal bone to the first, and a bursa often forms over the outer border of the dorsum. In the *acquired form*, which is generally due to infantile paralysis, the history of the case, the wasting, shortening, coldness and passive congestion of the limb, and often the absence of rigidity, will commonly serve to distinguish it from the congenital.

Talipes calcaneus.—The *congenital* variety is rare, except in

connection with spina bifida. The anterior part of the foot (Fig. 581) is drawn up and often a little everted or inverted, and generally held rigidly in this position by the contraction of the extensor muscles. In the *acquired* form (Fig. 581), which is commonly the result of infantile paralysis of the calf muscles, the heel is placed first on the ground in walking, but there is no drawing up of the foot by the extensors. The anterior part of the foot drops downwards from the transverse tarsal joint, and the tendo Achillis, instead of standing out tensely as in the normal foot, can often hardly be felt.

Talipes valgus or flat-foot.—The longitudinal and transverse arches of the foot are flattened and the anterior part of the foot is more or less everted. Though rare as a congenital, it is very common as an acquired deformity, and as such is, perhaps, most often due to the yielding of the ligaments of the sole and the relaxed state of the muscles which normally support the plantar arches, in consequence of general debility and want of muscular tone, combined with long standing or carrying heavy weights with the feet abducted. Hence its frequency in growing and under-fed lads, errand-boys, policemen, waiters, housemaids, and the like. Amongst other causes may be mentioned rheumatism, gonorrhœa, rickets, sprains of the plantar ligaments, and spasm or paralysis of certain muscles of the leg. It is also met with in badly-set cases of Pott's fracture. The calcaneo-scaphoid ligament and plantar fascia, and to a less extent the other ligaments of the sole, are elongated, and the bones on the inner side of the foot, instead of forming an arch, are depressed and in contact with the ground. The bones in front of the transverse tarsal joint are at the same time more or less abducted and everted, leaving the head of the astragalus, which is itself depressed, partly exposed on the inner side of the foot. The patients suffer from metatarsalgia (see below) and sweating feet.

FIG. 582.—Talipes valgus or flat-foot. (St. Bartholomew's Hospital Museum.)

In severe, and generally in congenital cases, the heel and front of the foot are drawn up by the tendo Achillis and the anterior muscles respectively, whilst the outer border of the foot is raised from the ground. The acquired form is often productive of so much crippling and pain as to render the sufferer unable to follow any employment which necessitates much standing or walking. The foot (Fig. 582) looks broader and longer than natural, the sole is flat, the inner border in contact with the ground, and the internal malleolus depressed; whilst two prominences, formed by the tuberosity of the scaphoid and the partially exposed head of the astragalus,

if on the posterior aspect, cause an aneurysm of the popliteal artery. The pedunculated form is easily removed with a chisel. A sessile multiple form of exostosis is seen in connection with rickets, and may end in sarcoma.

Cysts of the femur are hydatid, or may be the result of quiet necrosis, and may not be noticed until there is a spontaneous fracture, when amputation is generally indicated.

Swelling due to *callus* is occasionally seen after fracture in a rickety child and may be mistaken for a tumour.

Gumma of the femur, acquired or inherited, appears as a rapidly-developing thickening of the femur, which, if in the middle of the shaft, is likely to be confused with periosteal sarcoma. At the lower end of the bone it resembles not only periosteal sarcoma, but also endosteal myeloid sarcoma and central osteomyelitis. If the tumour be suspected to be syphilitic, the patient should be treated for ten or fourteen days with iodide of potassium and mercury in full doses. If no satisfactory improvement results, the tumour should be incised, when little yellow points of degeneration may be seen on the section. A piece of the tumour should be removed and should be examined microscopically, whilst the wound is filled with gauze and the antisyphilitic remedies continued till a report of its nature has been obtained.

Sarcoma.—The lower third of the femur is the typical seat of sarcoma. A *myeloid sarcoma* is of slow growth, uniformly enlarging the bone without pain or inflammation, a gumma is excluded by drugs, quiet necrosis by incision. The tumour on section will appear of a maroon colour, be cystic or contain blood. The shell in which it is enclosed may be evacuated, or the lower end of the femur excised and the surface of the tibia being cut off, the two bony ends are united; or amputation may be done with a practical certainty of curing the patient. A myeloid sarcoma at the upper end of the femur is similarly treated by evacuation of the shell, excision of the upper end of the bone, or amputation at the hip-joint.

Periosteal sarcoma is the most malignant of all growths. Secondary growths always follow in the inguinal and lumbar glands. There may also be enlargements of the liver, scattered growths on the surface of the lungs, with hæmorrhagic pleural effusion—indeed, the last seems to be a very common sequence. A periosteal sarcoma being found on exploration, amputation at the hip-joint, with excision of the glands in Scarpa's triangle should be done. In this way life may be prolonged from the time of operation for six to twelve months; the longest time we have ourselves known is fifteen months, the stump remaining sound and the signs of secondary growth being ushered in by a pleural effusion. Cases of sarcoma stated to be cured by amputation are central myeloid sarcoma, gumma, quiet necrosis, callus tumour, or alveolar hydatids.

Buchanan's subcutaneous section; Fitzgerald's operation; Kent Hughes' operation; or forcible rectification.

Tenotomy (Fig. 583) is indicated where there is much rigidity and the foot cannot be brought into its natural position by manipulation. Its object is the lengthening of the shortened tendon, not its mere division. The lengthening is effected by the organisation of the small-cell-exudation which is poured out between the divided ends of the tendon. Hence the importance of subcutaneous division, that is, of making a mere puncture in the skin and preventing the

FIG. 583.—Section through the lower third of the leg to show the relationship of the various tendons. (After Braune and Esmarch, and Kowalzig.) *f.* Fibula. *t.* Tibia. *i.m.* Interosseous membrane. Muscles and tendons: *t.a.* Tibialis anticus. *e.l.h.* Extensor longus hallucis. *e.l.d.* Extensor longus digitorum. *pn.l.* Peroneus longus. *pn.b.* Peroneus brevis. *t.p.* Tibialis posticus. *f.l.h.* Flexor longus hallucis. *g.s.* Gastrocnemius and soleus forming the tendo Achillis. *pl.t.* Plantaris tendon. *f.l.d.* Flexor longus digitorum. Vessels: *a.t.a.* Anterior tibial artery. *pn.a.* Peroneal artery. *p.t.a.* Posterior tibial artery. *i.s.v.* Internal saphenous vein. *e.s.v.* External saphenous vein. Nerves: *a.t.n.* Anterior tibial nerve. *m.c.n.* Musculo-cutaneous nerves. *p.t.n.* Posterior tibial nerve. *s.s.n.* Short saphenous nerve. *l.s.n.* Long saphenous nerve.

entrance of septic matter lest suppuration ensue and the tendon become adherent to its sheath or fail to unite. The tendon having been made tense by an assistant, pass the tenotome beneath it with the blade on the flat; then whilst the tendon is slightly relaxed, turn the edge of the tenotome towards the tendon and cut towards the skin, the assistant again making it tense to facilitate the division, but relaxing the moment it is felt to give way lest the skin be severed and the puncture be converted into an open wound. The puncture should be covered with a pad of antiseptic gauze, and the foot secured to a splint or in a plaster-of-Paris bandage. It was formerly the custom to place the foot on a splint in the

deformed, or in only a slightly improved position for a few days, until the puncture had healed and the tendon had united, before beginning mechanical extension to stretch the new material between the divided ends. It was thought that if the foot was at once rectified and the ends of the divided tendon consequently much separated, there was grave risk of the tendon not uniting, or of the uniting material remaining weak. This is not, however, the case, and the foot may be safely placed immediately after tenotomy in the best position possible, often a gap of a quarter of an inch to half an inch, or even more, being left between the ends of the divided tendon. By at once rectifying the position of the foot, after dividing any contracted ligaments that may still hold the bones in their deformed position, much time is saved and the necessity of expensive extension-apparatus is avoided. In dividing the posterior tibial tendon, after a puncture has been made with a sharp-pointed tenotome, a blunt-pointed tenotome should be substituted for it lest the posterior tibial artery be pricked. Should this vessel be wounded, all that is necessary is to apply firm pressure to the foot and ankle by a pad and bandage. On no account should an attempt be made to tie it, as this would convert the subcutaneous into an open wound. Even where the anterior as well as the posterior tibial artery has been wounded in tenotomy, bleeding has been readily arrested by pressure, and no harm has ensued. In the fat ankle of an infant the posterior border of the tibia, the guide to the tendon of the tibialis posticus, cannot be felt; the tenotome should then be entered midway between the anterior and posterior border of the leg, and at right angles to the surface.

Tendon lengthening has the advantage of exactness, also the divided ends do not retract and fail to adhere so that their usefulness remains limited. It is done aseptically through an incision in the line of the contracted tendon, into which a Z-shaped incision is made and the cut ends allowed to slide over one another until the tendon is sufficiently lengthened, when they are fixed in position by kangaroo-tendon sutures.

Tendon shortening or advancement is not of much use—*e.g.*, shortening of the tendo Achillis in talipes calcaneus—since the muscles are weak or paralysed, but it may be so far successful in that it offers a resistance to further deformity from the unopposed action of the antagonistic muscles.

Tendon transplantation or transference consists in partly raising the tendon of an active muscle and uniting it to or passing it through a buttonhole made in a paralysed tendon, by which it is hoped to reinforce the muscle weakened by paralysis, whilst lessening the over-action of the antagonistic muscles. It has been found that the most satisfactory results are obtained by substituting a muscle by one of the same group, the transference

of which shall not entail working at an unfavourable angle. Even if no marked increase of movement is obtained deformity produced by the antagonistic muscles is stopped without the necessity for apparatus. For reinforcing the tendo Achillis (Fig. 583) the peroneus longus is used, for the tibialis anticus the extensor longus hallucis, for the tibialis posticus a strip from the gastrocnemius and tendo Achillis. The peroneus longus is reinforced by the flexor communis digitorum, or *vice versâ*.

Syndesmotomy consists in dividing the contracted ligaments which after tenotomy are frequently found to hold the foot in the deformed position. It is performed by passing a tenotome deeply into the foot over the situation of the ligaments to be divided, and cutting freely through them whilst they are put on the stretch by an assistant manipulating the foot. The position of the foot should then be rectified by wrenching, and a plaster-of-Paris bandage applied.

Tarsectomy has for its object the removal of certain bones or portions of bones from the tarsus, so as to allow the foot to be at once restored to its normal position. It should only be undertaken in inveterate cases after milder measures have failed. The operations most frequently performed are Davy's, or the removal of a wedge-shaped piece of bone from the tarsus; and Lund's, or the excision of the astragalus.

Tarsotomy is the operation of dividing the tarsus transversely with a chain saw, and, like tarsectomy, should only be done in inveterate cases and never in the infant.

Phelps' open incision.—This consists in making an incision through the soft tissues on the inner side of the foot down to the bones. The tibialis anticus and posticus, the abductor hallucis and the calcaneo-scaphoid ligaments are divided. The wound is then stuffed with aseptic gauze and allowed to granulate from the bottom.

Buchanan's subcutaneous section.—A tenotomy knife is passed between the skin and the plantar fascia half across the sole of the foot, and all soft parts—the muscles, arteries, nerves, and ligaments are then divided down to the calcaneo-scaphoid joint.

Fitzgerald's operation consists in dividing subcutaneously with a chisel the neck of the astragalus and the os calcis just behind the posterior articular facet for the astragalus, and in then drilling the cuboid in several places, breaking up subcutaneously the scaphoid with a chisel and hammering it back into place.

Kent Hughes' operation consists in removing a wedge-shaped piece of bone from the neck of the astragalus and anterior end of the os calcis, and then rectifying the foot after any contracted tendon or ligament that may prevent reduction has been divided.

Ogston has recommended the excision of Chopart's joint. In young children he scoops out the ossifying centre from the tarsal bones, leaving cartilaginous shells which are crushed together.

Forcible rectification.—This is done by a Thomas's wrench or by Grattan's, Rédard's, or some other form of osteoclast. The ligaments preventing reduction are torn across, and sometimes the bones are broken.

(C) *Mechanical treatment.*—Until recently it was usual to keep the foot in the deformed position till the tendons had united, and then bring the foot slowly into its normal position by gradually stretching the united tendon. The apparatus usually employed was some form of Scarpa's shoe (Fig. 584) or other cog-wheel contrivance. By the majority of surgeons, however, plaster of Paris is now substituted for such expensive apparatus, the foot being secured at once in the plaster in the best possible position. In slight cases division of the tendon will alone be sufficient to allow of this; in more severe cases the division of the ligaments will also be necessary, whilst in very severe cases removal of a portion of bone will be required. If plaster of Paris is used a cotton-wool bandage should always be employed beneath the plaster to prevent injurious pressure on the parts. The mechanical supports necessary after the foot has been rectified will be briefly mentioned under the treatment of each variety of talipes.

Fig. 584.—Scarpa's shoe.

Physiological after treatment is most important for the purpose of restoring the natural movement of the joints and the functional activity of the muscles. It consists in active and passive exercises, massage, Faradization, hot and cold sponging, and lastly, in teaching the patient the proper use of the restored foot.

The special treatment appropriate to each variety of talipes.—In *talipes equinus*, division of the tendo Achillis is usually all that is required; but if there is much contraction of the sole (*talipes cavus*), the plantar fascia, or any tense band that can be felt, should first be divided, and when the sole has been straightened out by keeping the foot for a fortnight or so in plaster of Paris, the tendo Achillis may then be cut, and the foot again placed in plaster in the restored position for another two or three weeks. A boot with double leg-irons and toe-raising spring must be subsequently worn in paralytic cases, the irons being carried above the knee and the outer iron above the hip to a pelvic band if the flexors or extensors of the leg are also affected (Fig. 585).

In *congenital talipes varus*, or *equino-varus*, as it is generally called, treatment cannot be begun too early. In very slight cases the foot should be held in the restored position for some hours daily by the nurse's hand, or in slightly severer cases fixed in the restored position by plaster of Paris or a varus splint. If this, combined with some wrenching, does not suffice, the tibialis anticus and

posticus should be divided, and the inversion of the foot overcome by some form of varus splint, or plaster of Paris. When this has been thoroughly done the tendo Achillis should be cut, and the heel brought down as in *equinus*. Where there is much contraction of the sole, the plantar fascia, or other tense band, should be divided after the tibials but before the tendo Achillis. A similar instrument to that described for equinus should then be worn for a year or more, or as long as any tendency is shown to relapse. In paralytic cases, where the whole leg tends to twist inwards from the hip-joint, the outer iron should be carried to the pelvis. In neglected and relapsed cases of congenital varus the ligaments on the inner side of the sole and the posterior ligament of the ankle may be divided subcutaneously, as suggested by Mr. R. W. Parker (*syndesmotomy*); or, if this is not enough, the whole of the soft tissues on the inner side of the sole may be divided subcutaneously down to the bone (*Buchanan's operation*), or the contracted tendons and ligaments below and in front of the internal malleolus may be divided by an open incision (*Phelps' operation*). As a last resource, a wedge from the end of the astragalus and the anterior end of the os calcis (*Kent Hughes' operation*); a wedge-shaped piece from the transverse tarsal joint; or the astragalus, may be removed. If treatment is begun sufficiently early and is carried out with intelligence and perseverance an excellent result can be obtained by the simple measures advised above. In the neglected and relapsed cases simple measures should first be tried. These failing, the best operation in Walsham's opinion is Kent Hughes' operation or an astragalectomy.

FIG. 585. — Boot with double leg-irons to above knee, outside iron continued to pelvic girdle.

In *talipes calcaneus*, the extensor tendons, in the congenital form, must be divided if the foot cannot be rectified by plaster of Paris alone. In the acquired form a boot and irons, similar to that used in equinus but with a toe-depressing spring, may be worn. In paralytic cases the tendo Achillis may in some instances be shortened by removing half an inch or more and splicing the divided ends, or, better, the peronei may be sutured to the tendo Achillis so as to take the place of the paralysed calf muscles (*Nicoladoni's operation*).

In *talipes valgus* or *flat-foot*, such exercises as alternately raising the body on tip-toe, or walking on the outer edge of the foot, will in slight cases of the acquired variety when combined with the use of a valgus pad and a properly shaped boot, generally be successful. In severer cases a boot with outside leg-iron and rubber band to

brace up the sunken arch (Fig. 586), should be worn; whilst, where there is much rigidity, the foot should be wrenched into position with the patient under an anæsthetic and placed in plaster of Paris for a month. The wrenching may be repeated if necessary, and the boot above described subsequently worn. In very severe cases excision of Chopart's joint (*Ogston's operation*), the removal of a wedge-shaped piece of the neck of the astragalus and osteotomy of the tibia just above the ankle have been performed, and are said to be attended with success. Walsham has on only one occasion had to do Ogston's operation, having always found wrenching sufficient. By some surgeons, division of the peronei tendons is recommended, a procedure which, in his opinion, is quite unnecessary, and contrary to the principles which should guide us in the treatment of the deformity.

Metatarsalgia (*Morton's disease*), or persistent pain in the sole of the foot over the heads of the third or fourth metatarsal bones, has been attributed to the pinching between the bones or the treading on a nerve displaced by a slight degree of flat-foot. *Treatment.*—In early cases, as for flat-foot, if the pain persists, the head of the metatarsal bone may be excised.

Fig. 586.—Walsham's boot for flat-foot.

Hallux valgus is the subluxation of the great toe outwards at the metatarso-phalangeal joint. It is frequently connected with an enlarged bunion over the inner side of the joint. In the way of treatment a sock with a separate stall for the big toe should be worn, and the boots should be straight along the inner edge and square at the toe. Krohne's lever, Bigg's bunion spring, or Holden's toe-post in the boot will be found useful in correcting the inward displacement. If the toe-post is used a gloved stocking must be worn. For advanced cases, excision of the head of the metatarsal bone is attended with the best results.

Hammer toe (Fig. 587) is a condition in which usually the second toe is hyperextended at the metatarso-phalangeal joint and flexed at the first interphalangeal joint. It is due to contraction of the lateral ligaments and glenoid plate (not to contraction of the tendons), the result, in probably the majority of cases, of wearing too short or badly-shaped boots. It is sometimes hereditary, however, and due to a contraction of the ligaments, and only in a remote sense to the use of ill-formed boots. A bursa, surmounted by a painful corn, is generally found over the head of the prominent first phalanx (Fig. 587), and a valgoid condition of the great toe, which then generally overlies the second toe, is usually present. *Treatment.*—Wrenching the toe, dividing the ligaments subcutaneously, excising the joint, or amputating the toe according to the degree of deformity, is the usual treatment. The best way of

dealing with this troublesome affection, however, is to make an incision over the inner side of the first interphalangeal joint down to the bones. The lateral ligaments are next divided, and the head of the first phalanx made to protrude. It is then cut off with bone scissors, and the wound accurately closed. The foot is placed on a splint provided with slots for securing the toe by means of a bandage in the straight position. The corn and bursa are removed at the

Fig. 587.—Hammer toe. (St. Bartholomew's Hospital Museum.)

time of the operation, through a small oval incision round the corn. Amputation of the toe excludes admission to the services.

Corns (p. 461).

Perforating ulcer (p. 456).

Madura foot or **Mycetoma** and **Ainhum** (p. 97).

Ingrowing nail is most frequently met with in the great toe as the result of wearing tight boots and of cutting the nails square. The tight boot presses the skin over the sharp corner of the nail on each side, and ulceration, attended by the formation of exquisitely tender and exuberant granulations, results, giving the part the appearance as if the nail had grown into the flesh. The condition is a very painful one, and troublesome to cure. The *treatment* consists in wearing square-toed boots, so as to provide plenty of room for the toes, and then pressing a piece of tinfoil or lint between the edge of the "ingrowing" nail and the overhanging portion of skin. Should this not succeed a longitudinal strip of nail should be removed, and the prominent granulations and redundant skin shaved away to the level of the nail, together with that portion of the matrix corresponding to the strip of nail removed. As the operation is excessively painful, it should be done under nitrous oxide anæsthesia, or the ethyl chloride spray for slight cases may be used. If the trouble recurs the whole nail-bed is dissected out.

Hypertrophy of the toe-nail occasionally occurs as the result of neglect or chronic congestion of the matrix, and may assume the form of a horn. The *treatment* consists in cutting away the hypertrophied portion or in removing the whole nail, or, upon recurrence, the nail-bed.

Subungual exostosis forms a painful swelling which **raises the** middle while the two sides of the nail are unaltered. It **generally** affects the great toe. Complete removal of the ungual **phalanx with**

FIG. 588.—Subungual exostosis of the great toe.

FIG. 589.—The end of a great toe to show the characteristic appearances of a subungual exostosis.

the nail and nail-bed is the only satisfactory measure, the plantar surface being turned over as a flap.

Amputations of the Foot.—*Disarticulation at the ankle-joint* (*Syme's amputation*) consists in removing the foot at the ankle-joint, cutting off the ends of the tibia and fibula, and retaining the integuments of the heel as a covering for the bones. An

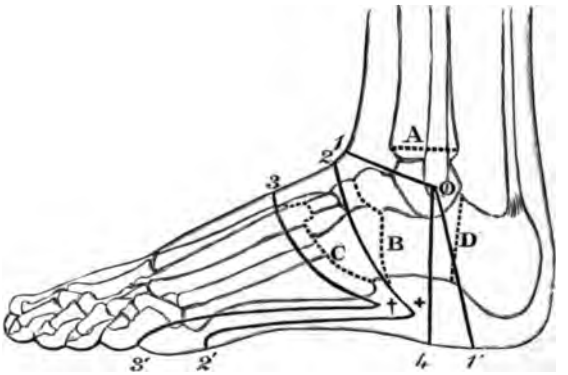


FIG. 590.—Diagram of the articulations of the foot and the lines of incision in the various amputations.

A, line of incision through malleoli in Syme's amputation. 1 to 0, 0 to 1', lines of incision through soft parts in Syme's amputation. D, line of incision through os calcis in Pirogoff's operation. 1 to 0, 0 to 4, lines of incision through soft parts in Pirogoff's operation. B, line of articulation between os calcis and astragalus behind and cuboid and scaphoid in front. 2 to +, + to 2', lines of incision in Chopart's operation. C, line of articulation between tarsus and metatarsus. 3 to †, † to 3', lines of incision in tarso-metatarsal operation.

incision down to the bone is made across the under surface of the heel from the tip of the external malleolus to a little behind and below the internal malleolus, *i.e.*, to a point exactly opposite its commencement. This incision should incline slightly backwards so as to cross the os calcis just in front of the tubercles. A second incision is next made across the front of the ankle,

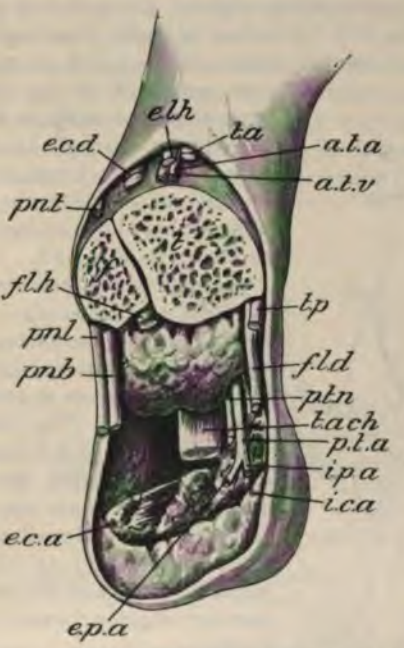


FIG. 591.—Syme's amputation, showing the structures divided. *f.* Fibula. *t.* Tibia. *t.a.* Tibialis anticus tendon. *e.l.h.* Extensor longus hallucis. *a.t.a.* Anterior tibial artery. *a.t.v.* Anterior tibial vein. *e.c.d.* Extensor communis digitorum. *pn.l.* Peroneus longus. *pn.b.* Peroneus brevis. *f.l.h.* Flexor longus hallucis. *t.ach.* Tendo Achillis, beneath which is a bolster of fat. *t.p* Tibialis posticus. *f.l.d.* Flexor longus digitorum. *p.t.a.* Posterior tibial artery dividing into *e.p.a.* and *i.p.a.* External and internal plantar artery. *e.c.a.* and *i.c a.* External and internal calcaneal branches forming the blood supply of the thick heel-flap.

the joint opened, the lateral ligaments divided and the os calcis cleared from its posterior and lateral connection by cutting from above downwards. Syme, however, formed his heel-flap by dissecting it from the bone from below upwards, a more difficult procedure than cutting from above downwards as is now generally done (Fig. 590, 1 to 0, 0 to 1′, and Fig. 592, S). The knife should be kept close to the bone to avoid injuring the posterior tibial artery or button-holing the integuments. The malleoli and a thin slice of the tibia are finally sawn off (Fig. 590, A). The anterior tibial and the

plantar arteries require ligaturing; the latter are situated at the extremity of the inner side of the heel-flap (Fig. 591).

Pirogoff's operation is a modification of Syme's. It differs in that the posterior part of the os calcis is left in the heel-flap to unite with the sawn end of the tibia. It is performed in a similar manner, save that the sole-incision is carried slightly forward instead of backward (Fig. 590, 0 to 4, and Fig. 592, P), and after the ankle-joint is opened, and the os calcis exposed, the posterior part of the latter is sawn off (Fig. 590, D) instead of being dissected out. The sawn surface of the os calcis is then turned up and placed in contact with the sawn end of the tibia, to which it may advantageously be fixed by an ivory peg driven through the heel-flap and os calcis into the lower end of the tibia. Instead of dividing the os calcis from above it may be sawn through from below as shown in Fig. 593.

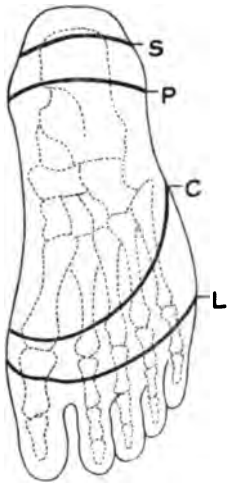


FIG. 592.—Lines of incisions crossing the sole. S. Syme's amputation. P. Pirogoff's amputation. C. Chopart's medio-tarsal amputation. L. Lisfranc's and Hey's tarso-metatarsal amputation.

Subastragaloid amputation (*Amputatio sub talo of Farabeuf*).—The foot is removed leaving the astragalus in position by cutting an internal plantar flap. The incision commences at the base of the fifth metatarsal bone (Fig. 590, 1), and runs back along the outer border of the foot to the tendo Achillis, where it curves upwards then forwards one finger's breadth below the external malleolus (Fig. 590, 0) over the dorsum of the foot to the scaphoid bone, and thence across the sole curving slightly forward to the starting point.

The *Medio-tarsal amputation* (*Chopart's*) consists in amputation of part of the foot through the transverse tarsal joint, *i.e.*, the joint formed by the os calcis and astragalus behind, and the cuboid and scaphoid in front (Fig. 590, B). A curved incision with its convexity forwards is made across the dorsum of the foot from immediately behind the tubercle of the scaphoid to a point midway between the tip of the external malleolus and the base of the fifth metatarsal bone (Fig. 590, 2 to +). The extremities of this incision are connected by tracing out from the sole a flap (Fig. 592, C) which should reach just short of the balls of the toes, and should be longer on its inner than on its outer side (Fig. 590, + to 2'). The dorsal ligaments are now divided, and the knife is passed beneath the bones and made to cut its way outwards, thus completing the flap already marked out on the sole. The astragalus and os calcis are, of course, left in the

stump. The chief objection that has been urged against the operation is the tendency of the tendo Achillis to draw up the os calcis, and consequently depress the anterior part of the stump so that the cicatrix becomes the lowest part. If care, however, is taken to make the dorsal incision nearly straight across the foot, this drawing up of the heel can to a great extent be prevented and an excellent and useful stump may be obtained, or Tripier's suggestion may be adopted and the under surface of the os calcis be sawn off so as to leave a flat surface for walking upon.

The *Tarso-metatarsal amputation* consists in removing the anterior part of the foot at the joints between the tarsus and metatarsus (Fig. 590, C), leaving the tarsus intact. It may be done—1, by disarticulating the metatarsal bones; 2, by sawing across the bases of all the metatarsal bones; 3, by disarticulating the four outer

FIG. 593.—Pirogoff's amputation as modified by Dr. E. Watson. (Smith and Walsham.)

metatarsal bones and sawing across the projecting internal cuneiform bone; 4, by disarticulating the three outer and the first metatarsal bones, and sawing across the prominent base of the second. The disarticulating method is usually called Lisfranc's operation; the disarticulating, with sawing across the internal cuneiform or base of the second metatarsal bone, Hey's. Hey, however, it appears, performed all of the first three operations, but not the last; and so much confusion has arisen as regards what is meant by Lisfranc's and what by Hey's operation that the terms had better be dropped. In the disarticulating method, which only need be described, an incision is made across the tarsus from the fifth metatarsal bone to an inch in front of the prominence of the scaphoid (Fig. 590, 3 to †); a sole-flap is next traced out, as in Chopart's amputation, but it should reach as far as the web of the toes (Fig. 590, † to 3′). The metatarsus is then disarticulated from the tarsus, the only difficulty in doing this arising from the second metatarsal bone dipping in between the cuneiform bones. The knife is now placed behind the

bones and made to cut its way out, thus completing the sole-flap (Fig. 592, L), or the flap if preferred may be dissected up from without inwards.

The *great toe* may be amputated (Fig. 576, 3) at its tarso-metatarsal joint by a flap taken from the inner side of the foot; or by an oval incision which is carried along the metatarsal bone to about the middle of its shaft, then made to diverge to the web between the first and second toes, and carried round the plantar surface of the big toe and back to the spot at the middle of the metatarsal bone. The incision should extend down to the bone, which should be next freed from its remaining connections and disarticulated, the knife being kept close to the metatarsal bone to avoid injuring the communicating branch of the dorsalis pedis with the external plantar artery. When the operation is completed merely a single longitudinal scar remains on the inner side of the foot. This may be modified by cutting obliquely through the metatarsal bone so as to preserve the attachment of the transverse ligament and then suturing the long tendons to it to prevent their retraction and disuse. Amputation at the metatarso-phalangeal joint may be done by double flaps or by an oval incision.

DISEASES OF THE SPINE.

Scoliosis or lateral curvature is a complicated distortion in which the spine forms two or more lateral curves with their convexities in opposite directions, whilst the vertebræ involved in the curves are rotated on their vertical axes so that the spinous processes are directed towards the concavity of the curves.

Cause.—The immediate cause that underlies the formation of lateral curvature is the *unequal compression of the intervertebral cartilages for long periods.* This unequal compression may be induced by 1, any condition causing permanent or habitual obliquity of the pelvis and the consequent throwing of the spine over to the opposite side; such as unequal length of the legs, knock-knee, flat-foot, the use of a wooden leg, habit of standing on one leg, sitting cross-legged, congenital dislocation of the hip, etc.; 2, a one-sided position of the body in sitting, standing, or lying, or produced by certain employments, as nursing or carrying with one arm, etc.; 3, contraction of one side of the chest following empyema; 4, unilateral contraction of the spinal muscles following paralysis of the opposing muscles. The conditions mentioned under 1 and 2 are, however, by far the most frequent causes of the deformity. Although lateral curvature may be induced by those causes acting alone, there are certain circumstances that appear especially to predispose to the deformity by producing a general want of tone in the muscles, structural weakness of the ligaments, and a softened condition of the bones. Such are, 1, heredity; 2, general debility;

PLATE XX.

Scoliosis. (From a skiagram taken by Dr. Hugh Walsham.)

[*To face p.* 1181.

3, rickets; and 4, rapid growth. It is much more frequently met with in girls than in boys, and is most common from about the age of fourteen to eighteen.

Pathology.—The long continued unequal compression of the intervertebral cartilages causes them to become wedge-shaped, and the portion of the spine corresponding to the compressed cartilages to assume sooner or later a permanent lateral curve. Whilst, however, a curve is thus being produced, say, in the dorsal region with its convexity to the right, a compensating curve in order to maintain the equilibrium of the spine is being simultaneously produced in the lumbar region with its convexity to the left (Fig. 594). Coincidently with these changes a rotary movement of the affected vertebræ upon their vertical axes is taking place, so that while the bodies turn towards the convexity of the curve, the apices of the spinous processes turn towards the concavity (Plate XX.). Hence, in addition to the formation of the primary and the secondary or compensating curves, we have a twisting round of the spine within these curves, as a consequence of which the ribs on the convex side are carried backwards with the transverse processes, causing the angle of the scapula on that side to project; whilst the ribs on the concave side are for the same reason carried forwards, producing a prominence of the corresponding breast (Fig. 595). The cause of the rotation has been

Fig. 594.—Lateral curvature of the spine. (St. Bartholomew's Hospital Museum, No. 1116.)

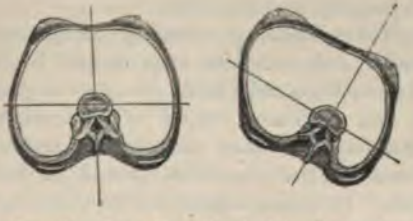


Fig. 595.—To show the effect of rotation in lateral curvature of the spine.

variously explained. The theory, perhaps, most generally accepted is that of Dr. Judson, who believes that the rotation is due to the fact that the posterior portion of the vertebral column, being a part of the dorsal parietes of the chest and abdomen, is confined by the ligaments and muscles to the median plane of the trunk; whilst the

anterior portion projecting into the thoracic and abdominal cavities, being devoid of lateral attachments, is free to move either to the right or left of the median plane when the spine is inclined to either side. At first the bones are not affected, but when the compression of the cartilages has become permanent the bodies of the vertebræ also gradually assume a wedge shape, whilst the articular processes become contracted and flattened on the concave side and elongated on the convex. The ligaments and muscles on the concave side are shortened and atrophied, whilst on the convex side the ligaments are stretched and the muscles become hypertrophied.

Signs.—Pain or a feeling of weakness in the back, general lassitude, and a stooping gait, are amongst the early symptoms; but the patient is generally first brought for consultation on account of a slight projection of the scapula, or an apparent prominence of the iliac crest—a growing out of the shoulder or of the hip, as it is popularly termed. In slight cases there may be little or no lateral deviation of the apices of the spinous processes, and the little there is may be made to disappear on suspending the patient or placing her in the prone position. In the severer cases, however, the signs are unmistakable. Thus, in the more common forms, there is usually a dorsal curve with its convexity to the right, and a shorter lumbar, or dorso-lumbar curve, with its convexity to the left. The right shoulder is generally elevated, and the angle of the right scapula, right iliac crest and left breast are prominent, whilst the left lumbar muscles, in consequence of the backward projection of the left lumbar transverse processes, stand out as a prominent ridge and give a greater sense of resistance on pressing over them than normal. In other cases the compensating curves may be so slight that there is apparently a single curve only, with its convexity either to the right or left, involving the whole spine or chiefly the upper dorsal or the lumbar vertebræ, and producing more or less projection of the scapula or apparent prominence of the iliac crest, etc., according to its severity and situation.

Treatment.—Where there is evidence of general or muscular debility the health and muscular tone should be improved by an open-air life, tonics, digestible food, etc., but especially by a carefully designed and regulated course of gymnastic exercises, the avoidance of fatigue, long hours of standing, and the like; whilst the exciting cause of the curvature should be looked for and if possible removed. In slight cases, the above means, when conjoined with recumbency for fatigue, will generally serve to cure or improve the curvature, or at least prevent it from getting worse. But in severe cases, when osseous changes are already confirmed, some form of rigid support, as a poroplastic jacket, or a light spinal instrument, will commonly be required, especially for the poorer classes of patients. In ordering such supports, however, the patient should be made to thoroughly understand that no real improvement

of the curvature must be expected from them, their only aim being to relieve pain when present, to give a sense of comfort and support, to improve the outward appearance, and to prevent further deformity. In slight cases they should on no account be used. The exercises are directed in part to improving the muscular tone generally, and in part to strengthening those muscles in particular that tend to lessen or straighten the curves. For the former purpose, such exercises as swinging by the hands from a bar, forcibly stretching an elastic cord fixed to the floor, and dumb-bell exercises should be practised. For strengthening the muscles in particular that tend to straighten the curve, the back should be manipulated till that posture is found in which the curves are least marked, and the patient made to hold herself in this position for as long as possible. At first she will be only able to do this for a few minutes at a time; but by frequently assuming the posture, the muscles thus brought into play are gradually strengthened till at last the improved posture is maintained constantly and without effort. For further improving the tone of these muscles Prof. Busch and Mr. Roth recommend some such exercises as the following:— The patient's body held in the improved posture is brought over the end of a couch or table, and whilst she is prevented from falling by an assistant holding her legs, she alternately flexes and extends her body at the hips, the surgeon resisting her efforts. Walsham has also found the use of the sloping seat, as recommended by M. Bouvier and Mr. Barwell, of considerable service in counteracting the curves. A similar effect may be obtained by wearing a thick sole on one boot, and by varying the seat to the off-side of the horse when riding. After the exercises, or twice or thrice during the day, the patient should lie on her back for half an hour to an hour, and whilst sitting her back should be supported by a reclining chair. Walsham has had very considerable success in removing rigidity in cases where there is slight osseous deformity by applying a weight to the convexity of the curve, the patient standing with her legs straight and body horizontal and supported in this position by her elbows on a chair. Some have commenced in marked cases by forcible manipulations under an anæsthetic which must not go so far as to tear or fracture.

Kyphosis is a general curving of the spine with its convexity backwards, or an exaggerated condition of the normal dorsal curve. It depends upon an unequal compression of the intervertebral cartilages and, to a less extent, of the vertebral bodies which thus become wedge-shaped with their bases looking posteriorly. It is generally the result in children of rickets; muscular debility, slouching habits, etc., in young people; in old people, rheumatoid arthritis, and osteitis deformans, increased by occupations necessitating stooping (p. 348). The point of chief interest in children is to distinguish it from the serious angular curvature

In later stages the cord is pressed upon by portions of bone separated from the vertebræ, or by pus making its way into the canal, or by inflammatory thickening of the membranes (*tuberculous pachymeningitis*). It may itself undergo softening, leading to permanent paraplegia.

Spinal abscess (*psoas and lumbar*).—When suppuration occurs, the pus collects in front of the diseased vertebræ in the angle formed by the falling forward of the upper upon the lower portion of the spine. The anterior common ligament and periosteum, relaxed by the bending of the spine, yield to the pressure of the pus, and with the pleura or peritoneum become thickened and form the abscess wall. The pus, prevented from travelling upwards by the overhanging vertebræ, downwards in front of the column by the attachments of the anterior common ligament, and backwards by the posterior common ligament, and by the vertebræ being less diseased behind than in front, makes its way on one or other side of the column. There it either enters the sheath of the psoas, and, destroying the contained muscle, presents in the iliac fossa or groin as an iliac or a psoas abscess, or passes backwards through or external to the quadratus lumborum, and points in the loin where it is known as a lumbar abscess. In rare instances the pus may take a different course. Thus it may make its way into the ischio-rectal fossa, or pass through the great sciatic foramen, or travel along the course of a rib and reach the surface near the sternum or umbilicus. Less often an abscess forms on both sides of the spine at once. In the cervical region the abscess will point in the pharynx (*post-pharyngeal abscess*), or in the posterior triangle of the neck.

Process of spontaneous cure.—Under favourable circumstances the granulation tissue undergoes ossification without the production of any deformity; but after the deformity has taken place, and the vertebræ above and below the disease have come into contact by the falling forward of the upper portion of the spine, the destructive process, if the parts are kept at rest, may cease; and firm osseous ankylosis, but with a permanent angular curvature, will ensue.

Symptoms.—In the early stages, before the angular deformity is produced, pain is felt on percussion over the diseased vertebra, or better on the head of the rib in connection with it, or on gently pressing on the shoulders, or tapping on the head, or on applying hot sponges to the spine. Pain also is felt in the course of the intercostal nerves and hence in the case of the lower intercostals may be referred to the abdomen. It is increased on movement; hence the spine is held stiffly by the muscles. The movements of the child are characteristic. If asked to pick up anything he does not bend his back, but placing his hand upon his knee to support his spine, reaches the ground by bending his legs and holding his back straight. If asked to turn round, he rotates the whole body, not the back. He walks about supporting his spine by resting his

hands on the various portions of furniture, and soon gets tired of play, and is noticed to lie about on the floor. In older patients tingling or numbness may be complained of in the extremities, and a feeling as if a cord were tied tightly round the body. Later, a prominence of one or more vertebræ occurs, and the nature of the disease can no longer be doubted. If neglected, the prominence increases, and the well-known angular deformity is produced. Now, especially if the disease is high up the spine, some loss of motion in the lower extremities occurs, and may progress to complete paralysis of motion. Sensation is not usually affected, as the posterior columns, being remote from the disease, escape. Nor are the bladder and rectum usually implicated. If an abscess has not already formed, and especially if the disease is moderately low down, one may now present in the loin (*lumbar abscess*), in the iliac fossa (*iliac abscess*), or in the groin (*psoas abscess*). The first gives rise to a fluctuating tumour between the last rib and the crest of the ilium just external to the erector spinæ; the second to a swelling in the iliac fossa. The *psoas abscess* may be known by the swelling being at first external to the femoral vessels, by the impulse on cough, and by fluctuation being detected on pressing above and below Poupart's ligament. The abscess makes its way under the femoral vessels, and then generally points at the inner and upper part of the thigh, and there breaks. It may also burst into the urinary or intestinal tract. After the opening of these abscesses, unless the strictest antiseptic precautions are taken, hectic but too frequently sets in, and the patient succumbs to the long-continued suppuration producing exhaustion or lardaceous disease; or he is carried off by tubercle in the lungs or other organs. Under more favourable circumstances the abscess may heal, firm ankylosis of the spine occur, and the patient recover with a permanent hump-back.

Diagnosis.—In the early stages caries must be diagnosed from neuralgia, rheumatism, lumbago, aneurysm, malignant disease and hysteria; in the later stages the angular curvature may have to be diagnosed from the kyphotic curvature of rickets. From *neuralgia*, *rheumatism*, and *lumbago* it is not always easy to distinguish it. The history of a former rheumatic attack, the effect of remedies, and the absence of the signs given above, must then be relied upon. *Hysteria* may simulate it very closely. The absence of signs of caries, except pain; the inconstant and more diffused character of the pain; and the presence of other signs of hysteria or of uterine disease, are the points to be attended to. A careful auscultation of the chest and examination of the abdomen will usually serve to exclude *aneurysm*. From malignant disease of the vertebral bodies, leading to the breaking down of the vertebræ, caries cannot at first be diagnosed, as both give rise to the same symptoms, but the age of the patient and the presence

of a carcinomatous growth elsewhere would lead to suspicion of cancer. The curve of *rickets* is more generally kyphotic, and disappears more or less completely on gently holding the child up by its arms, or extending it with its face downwards across the nurse's knees. There are, moreover, concomitant signs of rickets, and absence of those of tubercle.

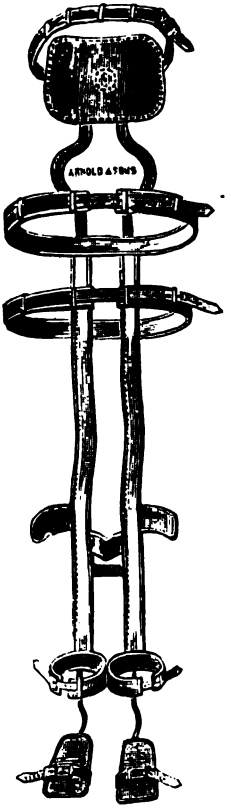


Fig. 598.—Double Thomas's splint for spinal caries.

A *psoas abscess*, in that it produces some flexion and eversion of the hip and may be attended with slight pain and apparently some rigidity on moving the leg, may be mistaken for *hip disease*. The freedom of movement at the hip when carefully examined, the absence of pain in the joint and the presence of a fluctuating swelling in the course of the psoas, and of some angular deformity when the spine is examined should render the diagnosis easy. From a *hernia* a psoas abscess may be distinguished by the swelling being external to the femoral vessels and by the fluctuation felt above and below Poupart's ligament.

Treatment. — Both constitutional and local measures are required. The former are those already described under *Tubercle* (p. 93). The chief local indication is to keep the spine at rest in order that the diseased vertebræ may be placed in the most favourable condition for repair. This may be attempted in two ways:—1, by absolute recumbency; and 2, by the use of some form of spinal support. 1. *Absolute recumbency* from six to twelve months up to two years or more in the supine or prone position on a suitably-constructed couch is the best method of treatment where the patient can be properly cared for, has airy apartments, can be taken out in this position in an invalid carriage, and can reside in the country or at the seaside. Especially is this treatment the best when the disease is situated high up in the spine, *i.e.*, in the upper dorsal or cervical region, and it is imperatively necessary where there is paralysis. To ensure absolute recumbency Walsham has largely employed a double Thomas's splint (Fig. 598), modified by the addition of a pelvic band, a support for the shoulders, neck and head, and two sliding foot-pieces. The two upright bars, which are prolonged to the head-support, are made after the outline of a normally-formed child

when in the recumbent position, and give support to both sides of the spine. Two cross-bars support the body, just below the axillæ and pelvis respectively; the legs are kept in position by the ordinary circlets and foot-pieces. The splint is placed next the skin so as not to require removal while the child is washed, dressed, etc. It not only fixes the spine and takes off the weight of the head and upper limbs, but also fixes the lower limbs, and thus prevents the psoas muscles from dragging on the spine. Absolute recumbency, when properly carried out, offers the best prospect of averting serious angular deformity and paralysis; as soon, however, as the acute symptoms quiet down some form of spinal support should be applied, and the patient cautiously allowed to take a certain amount of exercise. But amongst the poor, where the children are often left to themselves during the greater part of the day, absolute recumbency can seldom be ensured; and if it could, its advantage over other methods would be counter-balanced by the severe detriment to the health which the child would suffer in consequence of confinement to an ill-ventilated room, etc. For such patients some form of support, not only to restrain as much as possible the motions of the spine, but also to allow them to obtain a certain amount of fresh air, is generally necessary. 2. The *supports* most in use at the present day are Sayre's plaster-of-Paris case and Cocking's poroplastic felt jacket, though some surgeons still prefer steel instruments. The plaster-of-Paris case may be applied with the patient either in the upright position, suspended, with his heels just off the ground, by Sayre's tripod, or in the recumbent position by Davy's hammock apparatus. A skin-fitting vest having been previously applied, and a line drawn across the back with a pencil at the level of the axillæ to indicate the upper limit of the jacket, crinoline bandages, impregnated with plaster of Paris, are wound round and round the trunk till a sufficient thickness is obtained, dry plaster being from time to time rubbed in with the hands. The case should reach from the pencil line to just below the crest of the ilium, stopping short of the great trochanter and the pubes, and may be strengthened, if necessary, in places by inserting strips of perforated tin vertically between the bandages. Before applying the bandages, a folded silk handkerchief should be placed over the abdomen beneath the vest, so that when afterwards withdrawn space will be left for abdominal respiration (*Sayre's stomach-pad*). When the plaster case is dry it may be sawn through down the front, removed, and the fronts edged with leather, and perforated with eyelet-holes, so that it can be worn laced up, and be taken off from time to time. To apply the poroplastic felt, the jacket, which is first made to measure, must be put in a steam oven, and when rendered thoroughly plastic, further moulded to the patient, who should be prepared and suspended in the same way as for applying plaster of Paris. Of steel instruments, that known as

Taylor's is perhaps the best. Walsham, however, almost invariably employs the poroplastic jacket. Where the disease is in the cervical or upper dorsal region, Sayre's jury-mast may be fitted to the plaster-of-Paris case or poroplastic jacket; or a cervical collar composed of leather or poroplastic felt may be used, or better, the combined poroplastic jacket and collar.

Operative measures for spinal caries.—*The reduction of angular curvature* (Calot's method).—During the last few years, where angular deformity has been allowed to take place, the spine has been forcibly straightened by making extension on the head, arms, and legs whilst steady pressure is exercised on the curve. A plastic case or jacket is then applied. Many cases have now been treated in this way, some with success; but serious accidents, such as paralysis, abscess, recrudescence of the carious process, etc., have followed, and in some cases after apparent cure the curve has reappeared when the patient has been allowed to get about. In a few cases death has occurred. The relapse into disrepute which has followed these unsuccessful cases is the result of its indiscriminate and forcible application and the hasty publication of recent cases. Former writers—Sayre and others—have laid stress upon the straightening the spine as much as possible at each application of a jacket in all young children and recent cases, and that a careful watch for any loosening of the jacket be kept up to avoid relapse. Steady extension and pressure on the curve under an anæsthetic at each application of the plaster jacket, without using force to tear or fracture, may succeed in obtaining an ankylosed straight spine. It certainly can do no harm, and indirectly it will have the advantage that the child will be more closely watched.

A psoas abscess must not be treated by small incisions and the insertion of drainage tubes, nor must it be allowed to enlarge and burst. Septic infection of the abscess cavity is followed by a lingering exhaustion through hectic and death. Once made septic the measures below described prove insufficient, whereas, supposing the spinal disease itself to have been arrested, cure is very probable.

Irrigation and injection of iodoform emulsion.—A small incision should be made into the abscess from the loin, the cavity well washed out with sterilised water, whilst the abdomen is gently manipulated until it comes back clear; then the cavity is filled with freshly-made iodoform glycerine emulsion, all the excess pressed out, and the wound sewn up. The lumbar incision is the most dependent when lying in bed, and is much less likely to be infected than one in the groin, and less still than one in the inner side of the thigh. Moreover, the finger can explore for sequestra and spicula of bone in connection with the spine. The wound should be sewn up, not drained unless the cavity is already septic, when great care has to

be taken by antiseptic dressings to prevent further contamination through the tube.

Free incision and dressing with iodoform gauze.—This is indicated when injection has failed. At first sight it seems severe compared with the fatally easy method of incising a pointing abscess and inserting a drainage tube. But supposing the spinal disease quiescent, the result is most satisfactory. An incision is made from just above and outside the middle of Poupart's ligament round the crest of the ilium well into the loin. The muscles are divided, the peritoneum carefully pushed inwards, and the abscess incised throughout the length of the incision. The whole of the multilocular cavity is wiped out, and with due caution septa are broken down so as to reduce the cavity to a unilocular one as nearly as possible. When dry and clean, free from pus and carious material, the whole cavity is packed with long strips of iodoform gauze in such a way that they can easily be withdrawn. These need not be changed for three or four days; meanwhile the patient's bowels are opened. A young and sensitive patient will probably require to be dressed under an anæsthetic. After a week or so the whole cavity may appear lined by healthy granulation. Then if no pus appears to be forming or welling up anywhere the whole wound is secondarily sutured, a small strip of gauze or tube being inserted into the posterior end, and firm union between the granulations lining the abscess-walls and between those of the parietal incision takes place. Or the cavity is dressed every day or two until it heals up from the bottom to the surface.

Sequestrotomy.—When necrosis is associated with caries an incision is made in the loin or further up over the transverse processes and, guided by sinuses leading down to bare bone, sequestra may be scooped out; the cavity is then dressed with gauze.

Laminectomy.—In exceptional cases in which the paralysis of the lower limbs continues, in spite of absolute rest and recumbency, and in which there is intractable cystitis or severe pain not relieved by ordinary measures, the spines and laminæ of the affected vertebræ may be excised for the purpose of relieving pressure on the cord. The compression of the cord, however, would appear to more often depend on the presence of a tuberculous collection in front of the cord than on displacement of bone. Unless the tuberculous abscess, therefore, can be evacuated, the removal of the arches of the vertebræ is futile, and only tends to weaken the vertebral column. In place of laminectomy, an attempt may, in suitable cases, be made to reach the tuberculous collection from the front of the vertebræ. Ménard has succeeded in doing this by excising the transverse processes and proximal end of the ribs corresponding to the most prominent part of the spinal curve. Through the aperture thus made he was able to scrape and wash away tuberculous material with the result that the paralysis quickly disappeared.

Occipito-atloid, and **atlo-axoid disease,** are terms applied to chronic tuberculous inflammation attacking the articulations between the occipital bone and the atlas, and the atlas and the axis respectively. Hence, the disease resembles in its course tuberculous disease of the joints, rather than tuberculous disease of the bodies of the vertebræ. It may begin either in the synovial membranes, or as caries of the bones forming the articular processes, and when occurring between the atlas and the axis usually affects the synovial membranes between the odontoid process and the transverse ligament on the one hand, and the tubercle of the atlas on the other. Indeed in this situation it would appear to often begin as a caries of the odontoid process itself, and then spread to the synovial membranes. The disease is often attributed to a sprain of the neck, but though it may sometimes be excited by such, would appear more probably to depend on causes similar to those leading to tuberculous disease elsewhere.

Symptoms.—Pain is first felt over the seat of the disease, and radiating in the course of the nerves emerging from the intervertebral foramina between the affected bones. It is increased on attempting to turn or nod the head, but is relieved by supporting the chin with the hand. Hence the patient often holds his head between his hands, and if asked to rotate it, turns his whole body, keeping his neck stiff and immoveable the while. When the disease is chiefly limited to the articulations between the occipital bone and the atlas, the pain is principally confined to the region supplied by the suboccipital nerve, the hypoglossal nerve is paralysed, and is increased on nodding rather than on rotating the head. As the disease advances, the atlas, with the occipital bone, has a tendency to slip forward on the axis—directly forward if both sides are equally diseased, or more to one side if the disease is unilateral The spine of the axis in consequence appears more prominent than natural, and the head on a plane anterior to that of the rest of the spinal column. Should an abscess form it may point at the back of the pharynx (*post-pharyngeal*) or at the side of the neck. *Treatment.*—Absolute rest on the back, with the head between sand-bags, is imperative, as there is danger of fatal compression of the cord from the odontoid process or the transverse ligament giving way during some sudden movement of the patient. In some cases attended with paralysis below the disease, continuous extension by a chin and pole strap attached to a weight and pulley at the head of the bed, and counter-extension, with the patient in the recumbent position, has been successful in removing the pressure from the cord. When the acute symptoms have subsided, a moulded collar of leather or poroplastic felt, or an inflating india-rubber collar, will be required. Should an abscess form it should be opened in the neck at the posterior border of the sterno-mastoid, not through the mouth (see p. 795).

Acute septic osteomyelitis of the spine is a rare disease accompanied

by symptoms of Landry's paralysis, but also with fever and the formation of abscesses over the spines and laminæ, which are found to be extensively necrosed. Or if it is a vertebral body which is chiefly affected, the pus bursts not only into the spinal canal but also into the mediastinum, pleura or peritoneum.

Syphilitic disease of the spine is also rare, and is therefore likely to be confused with the result of slight injury, tubercle or new growth, unless some other indications of syphilis are met with.

Actinomycosis of the spine is an extension from the lung and pleura.

Malignant disease of the spine is commonly a metastatic growth often following cancer of the breast; the patient may develop a rapid spinal curvature with paraplegia, or there may be multiple tumours pressing on the posterior roots and causing great pain.

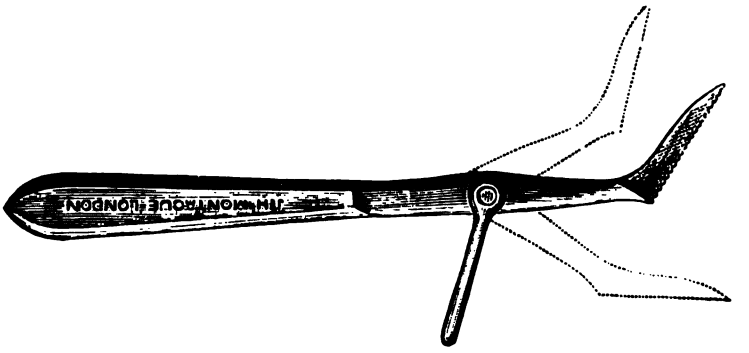


Fig. 599.—Horsley's laminectomy saw with moveable blade.

Primary or secondary sarcoma may also appear. *Treatment.*—Recumbency with the free administration of morphine.

Tumours of the spinal cord.—Fibrous tumours growing from the meninges and merely compressing the spinal cord or its roots, have in a few cases, first of all by Mr. Horsley after a diagnosis by Sir W. Gowers, been successfully removed. The diagnosis of their position has been made by the alterations in sensation and the pain or muscular paralysis and wasting occasioned. It is important to remember that in the cervical region the nerve-roots are about opposite the corresponding vertebral spines. As the spines become longer the corresponding spine is lower until the sixth dorsal spine, which corresponds with the ninth root, and the twelfth dorsal vertebra with the third lumbar nerve-root.

Laminectomy for spinal cord tumour.—In operating the patient must be specially guarded against shock. The spines and laminæ are freed through a longitudinal incision combined with notches cut in the back muscles to aid retraction. Bleeding may be checked by compression with hot sponges. Then the spines and laminæ are

carefully chipped away. At this stage it is perhaps sometimes safer to intermit the operation, for the patients are often weak. On the other hand there are obvious objections to two operations. The wound is sutured. After a few days it is reopened, the tumour sought for before and after laying open the meninges and so excised. Then the meninges, muscles and skin are separately sutured, and the patient carefully nursed as in the case of fractured spine. A tumour has been found higher up than the level previously indicated, also below the level when in the lumbar region on one of the roots of the cauda equina. A tumour infiltrating the spinal cord is let alone.

Spina bifida is a congenital malformation of the vertebral canal with protrusion of some of its contents to form a tumour distended

FIG. 600.—Spinal meningocele.

FIG. 601.—Meningo-myelocele.

In the three diagrams (FIGS. 600, 601, and 602) the letters have the same reference. A. Dura mater. B. Parietal, and C. Visceral arachnoid. D. Pia mater. E. Cord.

by cerebro-spinal fluid. It is nearly always met with in the middle line of the back, but very exceptionally the protrusion has occurred through the bodies of the vertebræ instead of posteriorly through the cleft spines. It is due to an arrest of development of the laminæ of the vertebræ (*mesoblastic elements*), and their consequent failure to unite in the middle line to form the spinous processes. This non-union may possibly be sometimes owing to an excess of cerebro-spinal fluid. A spina bifida may occur in any part of the spine, but is most common in the lumbo-sacral region, where the laminæ are the latest to unite. It may be associated with partial paraplegia or contracture, incontinence of urine and fæces, and with club-foot or other congenital deformities.

Pathology.—Three chief forms of spina bifida are described:—1, spinal meningocele; 2, meningo-myelocele; 3, syringo-myelocele. 1. In *spinal meningocele* the sac (Fig. 600) consists of dura mater and

arachnoid blended together, and consequently communicates with the sub-arachnoid space and contains cerebro-spinal fluid. The cord and nerves remain in the spinal canal. Very rarely the sac is said to consist of dura mater only, *i.e.*, of dura mater and so-called parietal layer of arachnoid; it would then communicate with the subdural space instead of with the sub-arachnoid. 2. In the *meningo-myelocele* (Fig. 601), the most common lumbar form, the sac also consists of dura mater and arachnoid, but contains in addition to cerebro-spinal fluid the spinal cord and nerves, which are often spread out over and intimately blended with the posterior part of the wall of the sac. As the cord passes through the sac some of the large nerve-roots given off from it run forwards across the interior of the sac to re-enter the spinal canal. Hence those nerves that are given off from the cord where it is adherent to the sac wall, appear to arise from the sac, and were in former times wrongly described as being distributed to it (see Fig. 601). 3. In the *syringo-myelocele* (Fig. 602), the most rare form, the central canal of the cord is greatly distended with fluid, the expanded cord being thus spread out over the sac wall, with which it is intimately blended. The nerves in this case pass through the walls of the sac to their destination.

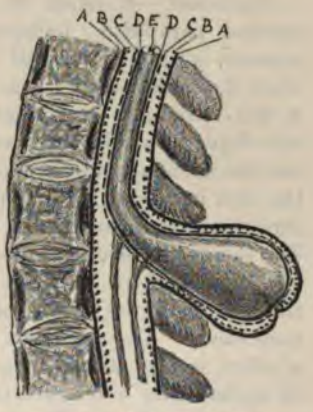


FIG. 602.—Syringo-myelocele.

The coverings of the sac may be healthy skin; but more commonly normal skin is only found at the sides, the central portion consisting of a thin bluish membrane. Sometimes a slight depression is seen on the lower part of the sac at the spot where the cord terminates in the wall. This is called the *umbilicus*, and at its bottom the central canal of the cord has at times been seen to open.

In some instances there is no protrusion, but rather a depression in the situation of the cleft between the vertebræ (*spina bifida occulta*), the cleft being occupied by the blended membranes, cord, and skin, and the spot covered with a tuft of hair, nævoid tissue or a nævo-lipoma. In obscure paraplegias, and in contractures and deformities of the feet, the back should be examined, since this condition may be present though overlooked by the mother.

Symptoms.—The swelling is usually of a globular or oval shape, translucent, sessile or slightly pedunculated and flaccid, but becomes tense and distended on coughing or crying. Pressing upon it sometimes causes the fontanelles to swell up, and may produce convulsions. When the spinal cord and large nerves are involved,

there may be paralysis of the extremities or of the bladder or rectum. The gap between the laminæ of the vertebræ may at times be felt on pressing on the sac. As a rule these tumours show a great tendency to enlarge, and rupture spontaneously, in which case death usually follows from the draining away of the cerebro-spinal fluid, and septic meningitis. A large one often ruptures during birth. Death, however, is sometimes due to hydrocephalus, marasmus and defective nutrition. When a spontaneous cure takes place it is usually due to the gradual shrinking of the sac.

Diagnosis.—Its congenital origin will at once distinguish a spina bifida from a new growth developed subsequently to birth; and its situation in the middle line, translucency, increase of tension on straining, and the gap between the laminæ when this can be felt, will usually serve to diagnose it from other congenital tumours.

Treatment.—Excision in all cases except where there is well-marked paraplegia, hydrocephalus or marasmus, or where the tumour is small and well covered by a firm pad of integument, when it should be left alone or merely protected by a pad or shield, is the recognised treatment. In spinal meningocele two vertical skin-flaps are made, the sac excised, the base ligatured or sutured, and the skin-flaps brought together by suture. In meningo-myelocele the skin is reflected from the sac, the latter opened, the nerves and cord dissected from the sac wall, and returned into the spinal canal. The sac is now excised, the meningeal pedicle ligatured or sutured, and the skin-flaps brought together over it, care being taken that the lines of suture in the meninges and skin are not placed opposite each other. The operation should be done with the child laid over a pillow so that the meningocele is the highest point, and it should be nursed after the operation in this way. This avoids the loss of cerebro-spinal fluid. The injection of Morton's fluid (iodine, grs. x.; iodide of potassium, grs. xxx.; glycerine, ℥j.) in quantities of ℥j., was formerly much employed, but was attended by considerable danger of spinal meningitis, and is now discontinued by most surgeons.

Coccygodynia, or pain in the joint between the sacrum and coccyx, is generally attributed to a blow or fall, or to injury received during parturition. When not from injury, the origin of the pain is unknown. There is pain on sitting, on rising from the sitting posture, during defæcation and on grasping the coccyx and moving it with one finger in the rectum and one outside. *Treatment.*—If rest, anodynes, and blisters fail, the coccyx may be removed through a dorsal incision, care being taken not to injure the rectum.

Sacrococcygeal tumours are congenital in origin, and grow with a variable degree of rapidity after birth. A pear-shaped tumour may form attached to the lower end of the sacrum and coccyx, or the sacrum and coccyx may be buried in a rounded tumour. Exceptionally the tumour grows within the cavity of the sacrum. The tumours are of a mixed structure, classed as teratoid, or in some part resembling

endotheliomata, being composed of hyalin cartilage, smooth and striped muscle, small dermoid cysts, or glandular tissue. Some are clinically malignant, grow with great rapidity, and are found to consist post-mortem mainly of myxosarcoma or to be largely carcinomatous. When definitely pedunculated, their structure may be principally multilocular cystic, without any malignant elements. This last class are amenable to surgery, and some have been successfully excised with part of the sacrum and coccyx. Special care must be taken to avoid loss of blood.

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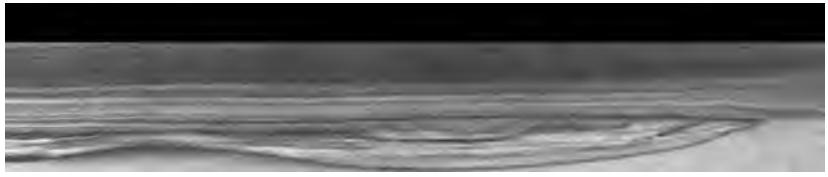

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